

This electronic thesis or dissertation has been downloaded from the King's Research Portal at <https://kclpure.kcl.ac.uk/portal/>



**London's Changing Waterscapes
the management of water in eighteenth-century London**

Van Lieshout, Carry

Awarding institution:
King's College London

The copyright of this thesis rests with the author and no quotation from it or information derived from it may be published without proper acknowledgement.

END USER LICENCE AGREEMENT



Unless another licence is stated on the immediately following page this work is licensed

under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International

licence. <https://creativecommons.org/licenses/by-nc-nd/4.0/>

You are free to copy, distribute and transmit the work

Under the following conditions:

- Attribution: You must attribute the work in the manner specified by the author (but not in any way that suggests that they endorse you or your use of the work).
- Non Commercial: You may not use this work for commercial purposes.
- No Derivative Works - You may not alter, transform, or build upon this work.

Any of these conditions can be waived if you receive permission from the author. Your fair dealings and other rights are in no way affected by the above.

Take down policy

If you believe that this document breaches copyright please contact librarypure@kcl.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

This electronic theses or dissertation has been downloaded from the King's Research Portal at <https://kclpure.kcl.ac.uk/portal/>



Title: London's Changing Waterscapes: the management of water in eighteenth-century London

Author: Carry van Lieshout

The copyright of this thesis rests with the author and no quotation from it or information derived from it may be published without proper acknowledgement.

END USER LICENSE AGREEMENT



This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported License. <http://creativecommons.org/licenses/by-nc-nd/3.0/>

You are free to:

- Share: to copy, distribute and transmit the work

Under the following conditions:

- Attribution: You must attribute the work in the manner specified by the author (but not in any way that suggests that they endorse you or your use of the work).
- Non Commercial: You may not use this work for commercial purposes.
- No Derivative Works - You may not alter, transform, or build upon this work.

Any of these conditions can be waived if you receive permission from the author. Your fair dealings and other rights are in no way affected by the above.

Take down policy

If you believe that this document breaches copyright please contact librarypure@kcl.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

**London's Changing Waterscapes — the management of water in
eighteenth-century London.**

Submitted by

Carry van Lieshout

Department of Geography, King's College London

For the degree of Doctor of Philosophy (PhD) of the University of London

December 2012

Abstract

This thesis explores the relationships between the natural environment, urbanisation, and the market economy, in the context of water supply and drainage in eighteenth-century London. It argues that, as a result of the expansion of the built-up area, the institutions that managed London's water became increasingly vital as the main mediators of the growing distance between the city's inhabitants and water. In particular, it focuses on the growth of a commercial water supply, and analyses how the allocation of a natural resource became increasingly refracted through the market. As such, the thesis addresses the emergence of a political economy of water and its social and economic ramifications.

The thesis takes an interdisciplinary approach, integrating social and environmental history, and it argues that geography should be incorporated in the analysis of the institutions that controlled water. It considers London's drainage system and its water supply together, as changes in the drainage of surface water played a crucial role in creating the conditions for the privatisation of London's water supply. The expansion of the supply network, in turn, depended heavily on London's social geography as well as its topography, as the difference in elevation between a water company's intake and its customer base proved influential for its failure or success.

The increased role of commercial water supply had important consequences as to how eighteenth-century Londoners accessed water. A new analysis of the water companies' level of market penetration adds context to contemporary debates surrounding the way the water market was structured. Finally, an investigation of the provision of free water in emergencies explores the role of private companies in the provision of public goods. The thesis adds to our knowledge about the growing role for institutions in an expanding city. More specifically, it explores how the market mediated relationships between society and nature.

Table of contents

Abstract.....	2
Table of contents	3
List of figures.....	5
List of tables.....	7
Style and abbreviations.....	8
Acknowledgements.....	9
Chapter 1. London's waterscape.	11
1.1. The study of cities, resources, and the natural environment.....	14
1.2. The eighteenth century: socio-economic transformations.	18
1.3. Administration and records.	27
1.4. Understanding London's waterscape.	28
Chapter 2. Mapping London's waterscape.	33
2.1. Shaping London's waterscape: topography and urbanisation.	34
2.2. Mapping London's water features.....	43
2.3. London's changing waterscape.....	51
2.4. Implications.	63
Chapter 3. The institutional framework: water companies and sewer commissions.	65
3.1. The water companies: historical background.....	67
3.2. The water companies: enlarging scale and raising capital.	75
3.3. The commissioners of sewers: historical background.	85
3.4. The commissioners of sewers: administration and enlarging scale.	92
3.5. Conclusion.	98
Chapter 4. Drainage, floods, and the expansion of the sewer network.	100
4.1. Draining Pimlico.	101
4.2. Expanding the network: private interest and public needs.....	106
4.3. Floods and flood control.	110
4.4. Maintenance and costs.	114
4.5. Implications.....	120

Chapter 5. Expanding the supply network: geography, technology, and water management.	122
5.1. Water infrastructure.	123
5.2. Geographical and environmental constraints.	129
5.3. Supplying the West End: canals versus engines.	135
5.4. Raising water: technological solutions and improvement.	147
5.5. Managing water: distribution, pricing, and balancing demands.	157
5.6. Extending the network.	167
5.7. Conclusion.	170
Chapter 6. The water market: expansion, structure, and debate.	172
6.1. Buying water: the household economy and the water market.	174
6.2. Published opinions on the water market.	188
6.3. London's water market: extent.	192
6.4. London's water market: price.	203
6.5. New entrants and support for competition.	213
6.6. Discussion: public opinion, proliferation, and needs.	225
Chapter 7. Private companies and public service.	227
7.1. Fire and ice: the provision of free water in eighteenth-century London.	229
7.2. Laws and leases.	238
7.3. Publicity.	241
7.4. Philanthropy, projecting, and a <i>zeitgeist</i> of improvement.	247
7.5. The men behind the companies.	252
7.6. The free provision of water: motives.	261
Chapter 8. Conclusion.	264
Appendix A. Directors of Chelsea Waterworks, 1720s-1800.	273
Appendix B. Directors of the New River Company, 1770-1800.	278
Appendix C. Managers of London Bridge Waterworks, 1780-1800.	281
Appendix D. Directors of Lambeth Waterworks, 1785-1800.	283
Bibliography.	284
1. Primary sources.	284
2. Secondary sources.	297

List of figures

Figure 2. 1. London's surface topography in the eighteenth century.	35
Figure 2. 2. The physical expansion of London during the eighteenth century.	39
Figure 2. 3. Christchurch on the 1746 Rocque map	40
Figure 2. 4. West End water features as depicted on the 1746 Rocque map.	41
Figure 2. 5. Comparison of Bermondsey area on Horwood and Stockdale maps.....	50
Figure 2. 6. Water features on the 1682 Morgan map.....	52
Figure 2. 7. Water features on the 1746 Rocque map.	53
Figure 2. 8. Water features on the 1792-99 Horwood map combined with the 1797 Stockdale map. Extent based on Horwood.....	54
Figure 2. 9. View of Ironmongers' Hall, c. 1753.....	55
Figure 2. 10. Applications to cover sewers in the Surrey and Kent commission's territory. ..	58
Figure 2. 11. The changing Fleet.	62
Figure 3. 1. Increasing scale: consequences and adaptations.....	66
Figure 3. 2. The water companies in 1700.....	76
Figure 3. 3. The water companies in 1800.....	76
Figure 3. 4. The London sewer commissions.....	91
Figure 4. 1. Belgrave Place on the Rocque and Horwood maps.....	103
Figure 5. 1. York Buildings Waterworks, c. 1755.	124
Figure 5. 2. London Bridge Waterworks, c. 1749.....	125
Figure 5. 3. Water infrastructure: New River Company's main.....	127
Figure 5. 4. Intake and distribution points of the water companies.	130
Figure 5. 5. Annual precipitation in London, 1700-1799.	133
Figure 5. 6. Dry years in eighteenth-century London.	134
Figure 5. 7. The New River Company's reservoirs, 1752.	136
Figure 5. 8. Intake points and reservoirs in the West End.....	143
Figure 5. 9. Chelsea Waterworks, 1782.	152
Figure 6. 1. PQ diagram for the London water market.....	176
Figure 6. 2. Market model.....	178
Figure 6. 3. Distribution of New River Company's tenants in 1769.....	198
Figure 6. 4. Percentage of buildings supplied by Chelsea Waterworks in 1804.....	200

Figure 6. 5. Lorenz curve for New River Company's 1769 income from water-rents.	205
Figure 6. 6. Chelsea Waterworks' 1804 water-rents for dwelling houses, breakdown by parish.....	208
Figure 6. 7. New River Company median water price by street, 1769.....	211
Figure 6. 8. The water companies, c. 1815.	216
Figure 6. 9. The effects of competition on Chelsea and Grand Junction Waterworks.....	218
Figure 6. 10. New River Company's dividends.....	222
Figure 7. 1. Eighteenth-century fire-fighting scene.	231
Figure 7. 2. Known locations of Chelsea Waterworks' directors, 1725-1800.	260

List of tables

Table 3. 1. London's private waterworks in the eighteenth century.	72
Table 3. 2. Collections in the Surrey and Kent commission.....	95
Table 6. 1. Estimation of houses supplied in 1804.	195
Table 6. 2. New River Company number of tenants and houses, 1769 and 1804.	197
Table 6. 3. Buildings supplied by Chelsea Waterworks in 1804.	199
Table 6. 4. Highest-paying customers of the New River Company in 1769.	205
Table 6. 5. Chelsea Waterworks' income and customer breakdown, 1804.....	206
Table 6. 6. Price breakdown for Chelsea Waterworks (1804) and New River Company (1769).	208
Table 6. 7. Breakdown of the New River Company's prices in the west and east, 1769	210

Style and abbreviations

- In accordance with general academic use, the style 'city' is used to indicate the whole metropolitan area of London, including Westminster, Southwark as well as the outparishes. In contrast, 'City' is used to specify the administrative unit of the City of London.
- Before Britain switched to the Gregorian calendar in 1752, the year officially started in April. In some sources, therefore, Jan.-March 1731 came after Dec. 1731. These cases are referenced as Jan.-March 1731/2. For sources where this did not occur, as well as in the main text, these dates are styled Jan.-March 1732.
- The commissioners of sewers are styled 'commissioners of sewers' as a generic term, and 'Commissioners of Sewers' when a specific commission is indicated, e.g. 'Surrey and Kent Commissioners of Sewers'. Sewer commission is used to indicate both the area and the administration, e.g. 'the Surrey and Kent sewer commission'.
- Similarly, the water companies are styled 'waterworks' as a generic term, and 'Waterworks' if a specific company is indicated, e.g. 'Lambeth Waterworks'.
- Eighteenth-century contracts for water supply were structured as leases, with the buyer as 'tenant' and the charge as 'rent'. Throughout the thesis, the word tenant is used interchangeably with customer. However, the tenant was not always the actual user of the water they bought, as some tenants sold on their water to others.
- The pound (£) was divided in 20 shillings (s). Each shilling contained 12 pennies (d).
- London Metropolitan Archives is abbreviated to LMA.
- The National Archives is abbreviated to TNA.
- The British Library is abbreviated to BL.
- Parliamentary Paper is abbreviated to PP.

Acknowledgements

This research was sponsored by the Arts & Humanities Research Council. A fellowship from the Economic History Society funded the final year. The support of these organisations enabled the progress and completion of this project.

I wish to thank above all my supervisors, David Green, Alex Werner, and Angela Gurnell, who each in their own way contributed towards this project. In particular, I would like to extend my heartfelt gratitude to David for his excellent advice, patience, and moral support throughout the years. This thesis would not be here without him.

Discussions at various conferences, seminars, and summer schools have helped to improve this work significantly, and made the whole PhD experience so much more enjoyable. I would like to thank attendees at the 2009 Urban History Conference, the 2009 International Conference of Historical Geographers, and the 2012 Economic History Society's Conference; those attending seminars at the Institute of Historical Research in 2011 and 2012; as well as my fellow participants at the European Society for Environmental History's summer schools in 2010 and 2011. Michael Edelstein, who took the time to teach me microeconomics at the EHS conference in Oxford, deserves special mention.

The comments and encouragement I took home from these events have been invaluable, and I am indebted to several organisations that provided financial support for me to attend. The Historical Geography Research Group's generosity allowed me to go Kyoto for the 2009 ICHG. The Department of Geography, King's College London, facilitated my attendance at the ESEH summer schools through two travel grants. I would like to express my gratitude to both.

Many people have made contributions towards this work. Clare Brant pointed me in the direction of John Robin's pamphlet. Sue Grimmond generously supplied the elevation model used in chapter five. Paul Laxton advised on the maps used in chapter two. Dolly Jørgensen and Nicola Tynan read through drafts of chapters five and six respectively, their time and help is greatly appreciated. I would also like to acknowledge the staff of the London

Metropolitan Archives, who were always friendly and helpful, and went out of their way to track down obscure references.

The Museum of London and the Guildhall Library provided access to the digitalised maps used throughout this thesis, while the British Museum and the Islington Local History Centre generously let me reproduce their images.

Family and friends encouraged me through the long process of research and writing. A special thanks goes to Sabirah Ali, and to my father, Herman van Lieshout.

Finally, Luca Romagnoli stuck with me and eighteenth-century London over the years, and in the process learnt more about sewers and Adam Smith than he ever wanted to know.

Grazie mille!

This thesis is dedicated to my grandmother, Laura Rietveld.

Chapter 1. London's waterscape.

Encountering water — flowing, standing and stagnant — was a common experience in eighteenth-century London. Contemporary maps show open sewers, ponds, canals, docks, basins, mill ponds, pools of water, and of course rivers.¹ In addition, there were fountains, conduits, as well as water pipes and underground sewers. This abundance of water in the city reflects the fact that its proximity is a biological necessity, and that organising, controlling, and mastering its circulation and flow was, and to some extent still is, the basis upon which urban growth is predicated.² Protection from flooding, the provision of water for daily activities such as washing, cooking, and industrial use, and the availability of ready supplies for fire fighting were all essential aspects of London's expansion during the eighteenth century. Creating the institutional frameworks and technological capacity to provide water and protect against fire and flood both underpinned this growth.³ It is the configuration, expansion, and management of these institutional frameworks and technological systems, and their impact on eighteenth-century London, that comprise the core of this research.

Water within cities has both a natural as well as a social history, and as such has a hybrid character. The study of this water landscape, or waterscape, includes both these aspects.⁴

The physical configuration of the urban waterscape is influenced by geological and

¹ An example is the 1746 Rocque map. Rocque, J., *A Plan of the Cities of London and Westminster, and Borough of Southwark; with the Contiguous Buildings; From an actual Survey, taken by John Rocque, Land Surveyor, and Engraved by John Pine, Bluemantle Pursuivant of Arms, and Chief Engraver of Seals, &c To His Majesty* (London, 1746).

² Swyngedouw, E., *Social power and the urbanization of water* (Oxford, Oxford University Press, 2004), p. 30.

³ Tarr, J.A. and Stine, J., 'At the intersection of histories: technology and the environment', *Technology and culture*, 39 (1998), pp. 601-640, p. 613.

⁴ Whiston Spirn, A., *The granite garden: urban nature and human design* (New York, Basic Books, 1984); Swyngedouw, E., 'The political economy and political ecology of the hydro-social cycle', *Journal of contemporary water research and education*, 142 (2009), pp. 56-60.

topographical factors, as well as institutional structures, such as economic conditions, legislation, and historical contingencies, many of which are culturally determined.⁵ But much as a system emerges as a result of both human and physical interactions, it also forms a constraining, and in some cases, a determining factor in the configuration of access to resources in itself: through the construction of technological systems of distribution and drainage, power relations regarding access to water and affordability are refracted.⁶ A study of a city's waterscape, therefore, asks questions that transcend the physical constraints of the environment and necessarily takes into consideration the social, economic, political and cultural processes that underpin all human interventions in the natural world. As geographer Alex Loftus has stated, the study of water networks provides "a wonderfully powerful lens through which the workings of different societies might be explored".⁷

London's waterscape has been the subject of recent research, but much has been focused either on the Middle Ages and early modern period, or on the nineteenth century.⁸

⁵ Hughes, T.P., *Networks of power: electrification in western society, 1880-1930* (Baltimore, Johns Hopkins University Press, 1993), p. 462.

⁶ Swyngedouw, *Social power*, pp. 30, 36. Key works on this topic include Wittfogel, K.A., *Oriental despotism: a comparative study of total power* (New York, Random House, 1957); Worster, D., *Rivers of empire: water, aridity, and the growth of the American West* (Oxford, Oxford University Press, 1985). For London Jenner, M.S.R., 'From conduit community to commercial network? Water in London, 1500-1725', in P. Griffiths and M.S.R. Jenner, eds., *Londinopolis: essays in the cultural and social history of early modern London* (Manchester, Manchester University Press, 2000), pp. 250-72; Kaika, M., *City of flows: modernity, nature, and the city* (London, Routledge, 2005).

⁷ Loftus, A., 'Thinking relationally about water: review based on Linton's What is water', *Geographical Journal*, 177 (2011), pp. 186-188, p. 186.

⁸ E.g. Graham-Leigh, J., *London's water wars: the competition for London's water supply in the nineteenth century* (London, Francis Boutle, 2000); Jenner, 'Water in London'; Magnusson, R.J., *Water technology in the Middle Ages, monasteries and waterworks after the Roman Empire* (Baltimore, Johns Hopkins University Press, 2001); Jefferson-Smith, P., 'Before Bazalgette: the Surrey and Kent Commission of Sewers, 1800-1847', *Transactions of the Newcomen Society*, 74 (2004), pp. 131-46; Lewis, D., "'For the poor to drink and the rich to dress their meat": the first London water conduit', *Transactions of the London and Middlesex Archaeological Society*, 55 (2004), pp. 39-68; Kaika, *City of flows*; Trentmann, F. and Taylor, V., 'From users to consumers — water politics in nineteenth century London', in F. Trentmann, ed., *The making of the consumer: knowledge, power and identity in the modern world* (Oxford, Berg Publishers, 2005), pp. 53-79; Hanley, J.G., 'The Metropolitan Commissioners of Sewers and the law, 1812-1847', *Urban History*, 33 (2006), pp. 350-68; Hillier, J., 'The rise of constant water in nineteenth-century London', *The London Journal*, 36 (2011), pp. 37-53; Taylor, V. and Trentmann, F., 'Liquid politics: water and the politics of everyday life in the modern city', *Past and Present*, 211 (2011), pp. 199-241.

The eighteenth century has often been ignored in this literature, or treated as a period when existing arrangements expanded but when little new was achieved. However, this apparent period of stability, or indeed, stasis, is illusory: the very fact of the city's expansion posed particular challenges for the ways in which water and drainage were provided. Population growth as well as expansion of the built-up area meant that households became increasingly distant from sources of water which, in turn, led to a greater dependence on the institutions responsible for constructing and managing the networks that bridged this spatial divide. At the same time, the risks of flooding similarly increased as city streets covered what was once open land, and as drainage of the urban area came to rely less on natural infiltration but increasingly on networks of gulleys, sewers, and sluices. The difficulties faced by the institutions responsible for the provision of water and drainage during this period, and the consequences of their increasing power in shaping London's waterscape, are the subject of this thesis.

London has been chosen as a case study through which these issues can be explored because of its size and rate of expansion. The city had long escaped from its administrative borders and by 1724 Daniel Defoe wrote that "when I speak of London, now in the modern acceptation, you expect I shall take in all that vast mass of buildings, reaching from Black-Wall in the east, to Tot-Hill Fields in the west (...) to Islington north".⁹ During the eighteenth century it grew to be the largest city in Europe: estimations show that London as a whole had 575,000 people in 1700, 750,000 people in 1750, and around 900,000 people at the time of the 1801 census.¹⁰ In addition to this growth in population, it has been said that eighteenth-century London grew faster in 'bricks and mortar' than in population, and by the

⁹ Quoted in Rudé, G., *Hanoverian London, 1714-1808* (London, Secker and Warburg, 1971), pp. 1-2.

¹⁰ Gray, R., *A history of London* (New York, Taplinger, 1978), p. 201; White, J., *London in the eighteenth century: a great and monstrous thing* (London, the Bodley Head, 2012), p. 3.

end of the eighteenth century the built-up area covered more than twice as much land as at the beginning.¹¹ Located in a tidal river basin, drainage was always an issue whilst population growth ensured that water supply became increasingly dependent on public and commercial, as opposed to private and individual, sources of supply. Exploring these issues over a long time period also allows for the fact that climatic variability, which imparted shocks to the systems for provision and drainage as a result of droughts or periods of exceptionally wet weather, can be included in the discussion of change.

1.1. The study of cities, resources, and the natural environment.

Exploring the relationships between urban places and the environment invites an interdisciplinary perspective, taking into account approaches from both history and geography. Environmental historians broadly examine the mutual relationships between the natural environment and society, noting how each affects the other.¹² Initially, as a result of environmental history's geographical origins in North America, scholars were predominantly concerned with issues of wilderness, exploration, and the impact of human activity on supposedly 'natural' environments.¹³ However, by the early 1990s, researchers began to turn their attention towards the relationships between cities and the environment.¹⁴ Urban environmental history, as it emerged at the end of the twentieth century, became the focus

¹¹ George, D.M., *London life in the eighteenth century* (Chicago, Academy Chicago, 1984), p. 15; Inwood, S., *A history of London* (Basingstoke, Papermac, 2000), p. 257.

¹² Steinberg, T., *Nature incorporated, industrialization and the waters of New England* (Cambridge, Cambridge University Press, 1991), p. 11; Smout, T.C., *Exploring environmental history, selected essays* (Edinburgh, Edinburgh University Press, 2009), p. 2.

¹³ Sörlin, S. and Warde, P., 'The problem of the problem of environmental history: a re-reading of the field', *Environmental History*, 12 (2007), pp. 107-130, p. 109.

¹⁴ See e.g. Melosi, M.V., 'The place of the city in environmental history', *Environmental History Review*, 17 (1993), pp. 1-23.

of much activity both in North America and also in Europe. Scholars, such as William Cronon, began to explore the relationships between cities and their hinterland in terms of the impact of urban growth on surrounding resources, but subsequent work such as that by Martin Melosi, Christine Meisner Rosen, and Joel A. Tarr focused more on how to understand better the internal dynamics of urban environments, identifying the provision of water, air pollution, and responses to flooding as key topics for research.¹⁵ In the process of re-orienting urban environmental history, scholars have questioned the view that cities were solely parasitic entities that fed on their local environment, sucking resources into their space and denuding the countryside of its food, water, and natural resources. Martin Melosi, for example, suggested that due to their concentration of people and activities, cities present opportunities for using resources more efficiently and organising services better than would be possible with more dispersed populations.¹⁶ Indeed, this thinking underpins much of the current debates about sustainability and compact cities.¹⁷ Dieter Schott similarly argued that cities should not just be seen as the locality in which problems such as pollution occur, but should be viewed as 'collective social actors' that engage in the acquisition, use, and organisation of their resources.¹⁸

While the re-orientation of urban environmental history challenges our views of the city, it is nevertheless true that much of the research has been concerned with urban solutions to

¹⁵ Cronon, W., *Nature's metropolis: Chicago and the Great West* (New York, Norton and Co, 1991); Rosen, C. M. and Tarr, J.A., eds., *The environment and the city: a special issue of the Journal of Urban History*, 20 (1994); Luckin, B., 'Pollution in the city', in M. Daunton, ed., *The Cambridge urban history of Britain, vol III, 1840-1950* (Cambridge, Cambridge University Press, 2000), pp. 207-228; Melosi, M.V., *The sanitary city* (Baltimore, Johns Hopkins University Press, 2000); Schott, D., 'Resources of the city: towards a European urban environmental history', in D. Schott, B. Luckin, and G. Massard-Guilbaud, eds., *Resources of the city: contributions to an environmental history of modern Europe* (Aldershot, Ashgate, 2005), pp. 1-27, p. 3; Massard-Guilbaud, G. and Thorsheim, P., 'Cities, environment, and European history', *Journal of Urban History*, 33 (2007), pp. 691-701.

¹⁶ Melosi, *Sanitary city*, p. 4.

¹⁷ See e.g. Jenks, M., Burton, E., and Williams, K., eds., *The compact city: a sustainable urban form?* (London, Spon Press, 1996).

¹⁸ Schott, 'Resources', p. 9.

problems as insanitary conditions and pollution, and has mainly focused on the large-scale sanitation projects of the nineteenth century.¹⁹ This emphasis has often implicitly or explicitly adopted the metaphor of the 'urban metabolism', an organising motif or model in researching the relationships between resources and the city. This metaphor considers the city as a 'social organism', which needs certain 'inputs' (resources such as clean air, energy, clean water, and food) as well as having 'outputs' (such as waste, polluted water, but also finished products), and considers the flow of materials (the water, food, and air) within the city.²⁰ The concept emerged alongside developments in scientific and biological knowledge in the nineteenth century, when it was used by the public health movement promoting the 'hygienist' city, as well as for various other urban improvement schemes.²¹ As a model, the idea resurfaced again in the 1960s and 1970s when material or energy flow analysis became a field for ecologists and environmentalists, and it was subsequently taken up by scholars interested in understanding the urban environment.²²

However, the urban metabolism model has certain limitations, the most important of which is that it is difficult to incorporate the social, political, and economic institutions that determine *how* the resource is used, what sort of activities take place, and *why* these

¹⁹ E.g. Porter, D.H., *The Thames embankment: environment, technology, and society in Victorian London* (Akron, University of Akron Press, 1998); Gandy, M., 'The Paris sewers and the rationalization of urban space', *Transactions of the Institute of British Geographers*, 24 (1999), pp. 23-44; Halliday, S., *The great stink of London: Sir Joseph Bazalgette and the cleansing of the Victorian metropolis* (Stroud, Sutton Publishing, 1999); Barles, S., 'A metabolic approach to the city: nineteenth and twentieth century Paris', in D. Schott, B. Luckin, and G. Massard-Guilbaud, eds., *Resources of the city, contributions to an environmental history of modern Europe* (Farnham, Ashgate, 2005), pp. 28-47; Serner, S.N., 'The construction of the modern city and the management of water resources in Italy, 1880-1920', *Journal of Urban History*, 33 (2007), pp. 813-827.

²⁰ Schott, 'Resources', pp. 9-10.

²¹ Gandy, M., 'Rethinking urban metabolism: water, space and the modern city', *City*, 8 (2004), pp. 371-87, p. 364. See e.g. Luckin, B., *Pollution and control, a social history of the Thames in the nineteenth century* (Bristol, Adam Hilger, 1986); Porter, *Thames embankment*; Swyngedouw, E., 'Modernity and hybridity: nature, regeneracionismo, and the production of the Spanish waterscape, 1890-1930', *Annals of the Association of American Geographers*, 89 (1999), pp. 443-465; Melosi, *Sanitary city*; Swyngedouw, *Social power*; Kaika, *City of flows*.

²² Fischer-Kowalski, M. and Huttler, W., 'Society's metabolism, the intellectual history of materials flow analysis, part II, 1970-1998', *Journal of Industrial Ecology*, 2 (1998), pp. 107-136.

happened.²³ The idea of a city as a form of ecological system implies that these institutions arise and processes take place naturally when, in fact, they are subject to a whole range of social factors, economic pressures, and political priorities. As such, the model's limitations form part of a wider criticism regarding environmental history as a whole, namely that it does not pay sufficient attention to human actions and motivations, as several recent publications emphasising the need for a deeper engagement with social and political theory within the discipline have made clear.²⁴ Geneviève Massard-Guilbaud and Stephen Mosley, for example, have argued that environmental historians often disregard the variety of different interests, desires, and experiences that motivate human actions.²⁵ They argue convincingly that environmental history should incorporate the conflicts, power struggles, and everyday practices and consumption behaviours that have shaped human-environment relationships over time and space.²⁶

This human factor is more clearly represented in social science approaches to the organisation of space and distribution of resources. Much recent work in geography, for example, has emphasised how space is produced by the interaction of social relations, ideas, relations of production and consumption, everyday life, and technology.²⁷ In this analysis, the process of urbanisation is seen as the transformation of nature and the social relations inscribed therein, which results in the conceptualisation of cities as a socio-physical construction of dense networks of interwoven socio-spatial processes which are

²³ Boyden, S., 'Nature, society, history and social change', *Innovation*, 14 (2001), pp. 103-16.

²⁴ E.g. Smout, *Exploring*, p. 2; Massard-Guilbaud, G. and Mosley, S., 'Breaking down borders: integrating the social and environmental in history', in G. Massard-Guilbaud and S. Mosley, eds., *Common ground: integrating the social and environmental in history* (Newcastle upon Tyne, Cambridge Scholars Publishing, 2011), pp. 1-15.

²⁵ Massard-Guilbaud and Mosley, 'Breaking down', p. 4.

²⁶ Ibid.

²⁷ Based on Lefebvre, H., *The production of space* (Oxford, Wiley, 1992). There is a wide literature on this: recent work on water includes Swyngedouw, *Social power*; and Linton, J., *What is water? The history of a modern abstraction* (Vancouver, UBC press, 2010).

simultaneously human, material, natural, cultural, and organic.²⁸ Emphasising a political-ecological perspective in which environmental and social changes co-determine each other, geographers, such as Erik Swyngedouw, have suggested that there is a dialectical set of relationships involved in the transformation of both social as well as physical environments.²⁹ The eighteenth-century urban waterscape, in this view, was shaped and transformed through the different processes that occurred over the course of this century.

1.2. The eighteenth century: socio-economic transformations.

The long eighteenth century — from Restoration to Regency — saw broad political, economic, social, and technological changes take place. In some ways these developments were connected, and in many ways changes in one sphere influenced those in others. Explaining the relationships between this set of interrelated developments has been the subject of much debate. Some historians have argued that these changes arose as a consequence of the emergence of the market or political economy during the eighteenth century.³⁰ Others, Douglass North and Barry Weingast for example, have attributed economic changes to a shift in political and fiscal institutions emerging out of the Glorious

²⁸ Swyngedouw, *Social power*, pp. 9-10, 23.

²⁹ Ibid., p. 23. In earlier work, Swyngedouw called this 'socio-nature', and the process of producing it 'hybridization'. Swyngedouw, 'Modernity and hybridity', p. 447. Recently, these concepts have been taken up by environmental historians and reworked into the 'socio-natural site', in which human action and material objects influence each other and form hybrids. Winiwarter V. and Schmid, M., 'Umweltgeschichte als Untersuchung sozionaturaler Schauplätze? Ein Versuch, Johannes Colers 'Oeconomia' umwelthistorisch zu interpretieren', in T. Knopf, ed., *Umweltverhalten in Geschichte und Gegenwart* (Tübingen, Attempto Verlag, 2008), pp. 158-173.

³⁰ Based on Polanyi, K., *The great transformation, the political and economic origins of our time* (Boston, Beacon Paperback, 1956).

Revolution of 1688.³¹ More recently, Joel Mokyr has framed the myriad changes in terms of a basic shift in ideology as a result of the new philosophies of the Enlightenment.³² Whatever the fundamental cause, the profound institutional changes that occurred over the eighteenth century deeply impacted on the social, economic, and political relations between people.

A key aspect of these changes, as Roy Porter has argued, was the emancipation of human consciousness, and the introduction of a world view in which mankind was given a larger degree of independent agency.³³ This meant a radical new approach to the world that emphasised rationality over divinity. Human societies, no less than the natural world, were seen as subjects that followed rational forms of explanation rather than those determined by religious authority or divine intervention. As such, the political and economic laws governing the interactions between the individual and society were subjects that could be studied through empirical means. A second key change was that once a rational understanding had been achieved, processes of change were seen as malleable and subject to improvement. The power of reason and knowledge were therefore applied to improve the human condition.³⁴ 'Improvement' and 'progress' thus became key terms in the eighteenth-century lexicon.³⁵

Alongside the intellectual changes associated with the Enlightenment, there were important political transformations that enhanced property rights and buttressed the enforcement of contracts. In England, the 1689 Bill of Rights that followed the Glorious

³¹ North, D.C. and Weingast, B.R., 'Constitutions and commitment: the evolution of institutions governing public choice in seventeenth-century England', *Journal of Economic History*, 49 (1989), pp. 803-32.

³² Mokyr, J., *The enlightened economy, an economic history of Britain, 1700-1850* (London, Yale University Press, 2009). In the context of water, this view was followed by Linton, *What is water*.

³³ Porter, R., *Enlightenment, Britain and the creation of the modern world* (London, Penguin Press, 2000); Linton, *What is water*, p. 9.

³⁴ Withers, C.W.J., *Placing the Enlightenment, thinking geographically about the Age of Reason* (Chicago, University of Chicago Press, 2007), pp. 1-2.

³⁵ Porter, *Enlightenment*, p. 426.

Revolution restricted the arbitrary power of the King and established a more powerful Parliament with much stronger powers over the country's finances. In addition, it made provisions for the increased protection of private property rights and the enforcement of contracts.³⁶ This fostered trust in the government, and over the following decades, as the state required more funds, individual lenders were able to invest confident that their loans were backed by the force of law. This constitutional change allowed for a 'national' debt, as opposed to a royal one, the (in)security of which rested in the fickleness of an absolute monarch.³⁷ The Bank of England was established in 1694 to mediate the national debt, which marked the embodiment of the greater degree of separation between Crown and national finances.³⁸ In practical terms, these shifts in fiscal arrangements signalled a clear commitment on the part of the state to enforce contractual arrangements — a necessary institutional change that, as Douglass North points out, underpinned investment in a wide range of activities, including, in this case, the supply of water.³⁹

Growing confidence in the legal enforcement of contractual obligations meant, in turn, that trust was easier to maintain even amongst individual borrowers and lenders who had no personal knowledge of each other. The new institutional arrangements therefore made it possible for investors to bridge the barriers of distance and lend to those who were in search of finance, even if they were unknown and at a considerable distance away.⁴⁰ The growth of overseas trade expanded the economic base, and the import and re-export of goods, largely conducted through regulated or joint-stock companies such as the East India

³⁶ North and Weingast, 'Evolution of institutions', p. 816.

³⁷ Dickson, P.G.M., *The Financial Revolution in England: a study in the development of public credit, 1688-1760* (London, Melbourne, 1967). The state required more money to fund its increased military activities: in addition to increasing the national debt, it also increased taxation. Brewer, J., *The sinews of power: war, money, and the English state, 1688-1783* (London, Unwin Hyman, 1989). See also Roseveare, H., *The Financial Revolution, 1660-1760* (London, Longman, 1991), p. 3.

³⁸ Brewer, *Sinews of power*, p. 207.

³⁹ North and Weingast, 'Evolution of institutions', p. 825.

⁴⁰ Mokyr, *Enlightened economy*, p. 25.

Company (incorp. 1698), created an accumulation of mercantile wealth.⁴¹ The rise of private banks alongside the Bank of England provided a secure means of storing this wealth, as well as providing credit for more investment, which became the key to economic growth. The trust in a secure constitution and stable political system, the assurance of property rights, and guarantees in the system of banking allowed the circulation of capital.⁴² This set of political and financial institutions that emerged during the later decades of the seventeenth century has been called the 'Financial Revolution', and its impact was profound in the late seventeenth and eighteenth centuries.⁴³ For the purpose of this thesis, these developments were crucial for the financing of infrastructural projects that required a large initial capital outlay, such as those that supplied water to London.

Related to this Financial Revolution was the rise of the market economy. The growth of trade and the greater circulation of money allowed for a rise in the consumption of goods.⁴⁴ But the rise of the market arguably had a deeper and more profound impact on society as well. While in a pre- or non-market economy societies embedded their economy into more significant social institutions, in a market economy most exchanges are ruled by the market itself. This shift, which Karl Polanyi has called 'the Great Transformation' and Joel Mokyr called 'the mother of all institutional changes', transformed society in fundamental ways.⁴⁵ Many goods, such as land, wood, grain, and also water, access to which had previously been embedded in other relations, became instead subject to market forces and were increasingly commodified, meaning that their distribution was determined largely, if not

⁴¹ Carruthers, B., *City of capital: politics and markets in the English Financial Revolution* (New Jersey, Princeton University Press, 1996), p. 116.

⁴² North and Weingast, 'Evolution of institutions', p. 825; Roseveare, *Financial Revolution*, p. 4.

⁴³ Dickson, *Financial Revolution*.

⁴⁴ McKendrick, N., 'The consumer revolution of eighteenth-century England', in N. McKendrick, J. Brewer, and J.H. Plumb, eds., *The birth of a consumer society, the commercialization of eighteenth-century England* (London, Hutchinson & Co, 1982), pp. 9-33.

⁴⁵ Polanyi, *Great transformation*, p. 68; Mokyr, *Enlightened economy*, p. 8.

entirely, through economic relations.⁴⁶ Processes of commodification were uneven and, in certain places and specific periods, tightly contested, but nevertheless during the course of the eighteenth century became more widespread.

These changes were apparent in the ideological transformation that took place as contemporaries discussed the meaning and implications of living in a commercial society. Ideas that contrasted the common good versus private gain were tempered by views that emphasised the essential unity of both.⁴⁷ Whilst some, such as Anthony Ashley Cooper, the third earl of Shaftesbury, contrasted the benefits of trade with an aristocratic dislike of making money, others were less judgemental about the vulgarity of commerce.⁴⁸ One of the first authors to analyse and advocate capitalist market relations was Bernard Mandeville, who wrote in the first few decades of the eighteenth century. In 1705 he published *The Grumbling Hive*, a pamphlet that was further explored in his 1714 *Fable of the Bees*, one of the earliest and most penetrating analyses of the emerging market economy.⁴⁹ In this work, Mandeville proposed that the 'vice' of private interest could in fact be seen as a public virtue. The purchase of commodities, he argued, including luxury items, provided employment and income for those involved in their manufacture and distribution. Without this acquisitive behaviour, economic prosperity would wither.⁵⁰ Profiting from the

⁴⁶ For grain, see Thompson, E.P., 'The moral economy of the English crowd in the eighteenth century', *Past and present*, 50 (1971), pp. 76-136. Access to wood is discussed in Griffin, C.J., 'Becoming private property: custom, law, and the geographies of 'ownership' in 18th- and 19th-century England', *Environment and Planning A*, 42 (2010), pp. 747-762.

⁴⁷ Miller, P.N., *Defining the common good, empire, religion and philosophy in eighteenth-century Britain* (Cambridge, Cambridge University Press, 1994), p. 2.

⁴⁸ Ogborn, M., *Spaces of modernity: London's geographies, 1680-1780* (New York, The Guilford Press, 1998), p. 83; Porter, *Enlightenment*, pp. 384-5.

⁴⁹ Hutchison, T., *Before Adam Smith — the emergence of political economy, 1662-1776* (Oxford, Basil Blackwell, 1988), pp. 115, 124.

⁵⁰ Ogborn, *Spaces of modernity*, p. 85.

production and sale of commodities, therefore, even though it was fuelled by private interest, contributed to the public good.⁵¹

Mandeville's work proved very influential, sparking intense debates about the validity of luxury consumption and its role in the progress of society, at the same time as it forced a reconsideration of the commercial basis of the market economy.⁵² Samuel Johnson, for instance, asserted that while he had thought Mandeville's ideas dangerous, they had opened his eyes as well: while the *Fable of the Bees* laid bare the emerging institutions on which the modern world was founded, these still brushed against society's predominant morality, even in the latter half of the century.⁵³ Nevertheless, interest in understanding better the rational basis of market relations continued and during the course of the eighteenth century a body of literature emerged to probe how the market economy functioned, investigating both micro- and macro-economic aspects of this new system.⁵⁴

The Enlightenment values of studying the laws of nature were evident in the rational and empirical way in which conceptual and theoretical issues were investigated, including the price-value mechanism, the division of labour, public finance, the benefit of trade for the nation, and the role of money.⁵⁵ Studies of economic relationships and the creation of wealth, which included Josiah Tucker's *Elements of Commerce* (1755), James Steuart's *Principles of the Political Economy* (1761), and Adam Ferguson's *History of Civil Society* (1767), culminated in 1776 when Adam Smith published *The Wealth of Nations*, the most

⁵¹ Stedman Jones, G., *An end to poverty? A historical debate* (London, Profile Books, 2004), pp. 44-5.

⁵² Berg, M. and Eger, E., 'The rise and fall of the luxury debates', in M. Berg and E. Eger, eds., *Luxury in the eighteenth century, debates, desires and delectable goods* (Basingstoke, Palgrave Macmillan, 2003), pp. 7-27, p. 7. See also Breen, T.H., 'The meanings of things: interpreting the consumer economy in the eighteenth century', in J. Brewer and R. Porter, eds., *Consumption and the world of goods* (London, Routledge, 1993), pp. 249-260.

⁵³ Hutchison, *Before Adam Smith*, p. 124.

⁵⁴ *Ibid.*, p. 187.

⁵⁵ *Ibid.*, p. 5.

influential study of the workings of the political economy of the eighteenth century.⁵⁶ Smith followed Mandeville's ideas that only selfishness could promote economic activity: the baker, he argued, made bread for his own profit and not out of benevolence.⁵⁷ But Smith went further: he introduced the concept of the 'invisible hand', that is, a self-regulating price mechanism by which the pursuit of private interests ultimately would result in the greatest benefit to society.⁵⁸ Self-interest became a laudable goal and the regulation of the market could therefore be left to the market itself.

This philosophical shift reflected fundamental changes relating to the expansion of the money economy and its growing intrusion into everyday life. New ideas about ownership, access to, and exchange of goods and services, which sometimes clashed with long established customs, were evident in a range of issues that emerged during the eighteenth century.⁵⁹ Debates about access to land and to the purchase of grain illustrate how these new ideas were played out in practice. Before the rise of the market economy, the grain market had been regulated and controlled through the assize of bread, which set a fair allowance for the producers, controlled the rate of profit that middlemen could make, and resulted in a 'just price' for the buyers.⁶⁰ As the price of grain became determined more by market sources than by regulation, and as producers and merchants sought to evade the restrictions imposed by these customary rules, popular protests emerged, particularly during times of shortage when millers and grain merchants were suspected of making surplus profits that deprived the poor of their rights to subsistence.⁶¹ Essential goods,

⁵⁶ Steuart's work was very influential during the 1760s, but later was eclipsed by Smith. Hutchison, *Before Adam Smith*, p. 336.

⁵⁷ Porter, *Enlightenment*, p. 389.

⁵⁸ Heilbroner, R. L., *The worldly philosophers* (London, Penguin Press, 1980), p. 42.

⁵⁹ E.g. Hay, D., 'Poaching and the game laws on Cannock Chase', in D. Hay et al, eds., *Albion's fatal tree* (Harmondsworth, Penguin Books, 1977), pp. 189-254; and Griffin, 'Becoming private property'.

⁶⁰ Thompson, 'The moral economy', pp. 83-4.

⁶¹ *Ibid.*, p. 78.

therefore, were subject to notions of a fair or just price, established through a set of customary expectations and forms of regulation that governed economic relations. Similar arguments could be made in relation to water, an issue around which many of the debates discussed later in the thesis revolved.

Bread and grain riots were not the only way through which the friction between a regulated and a market economy could be expressed. In a less directly oppositional way, debates took place in what Jürgen Habermas has called the 'public sphere'.⁶² Drawing on the intellectual space created by the decline in absolutist regimes, which made possible the discussion of issues that were previously the domain of state or religious discourse, and incorporating a growing group of educated and literary individuals, opportunities were created for a wider public debate about economic relationships.⁶³ In this realm private individuals could meet as equals and engage in rational debate and open and critical discourse about areas of common concern.⁶⁴ Economic discussions that were aired in the public sphere in turn helped to develop a body of critical knowledge through which individuals could become increasingly familiarised with the workings of the market.⁶⁵ This knowledge, in combination with the rise of the public sphere, allowed people to discuss economic issues such as monopolies, commodification, and the benefits of the free market versus regulation.

While the public sphere encompassed a myriad of spaces, such as coffeehouses, salons, public buildings, and the streets, there is very little record of the discussion that actually

⁶² Habermas, J., *The structural transformation of the public sphere* (Cambridge, MIT Press, 1991).

⁶³ Calhoun, C., 'Introduction: Habermas and the public sphere', in C. Calhoun, ed., *Habermas and the public sphere* (Baskerville, Massachusetts Institute of Technology, 1992), pp. 1-48, p. 7.

⁶⁴ Ibid., p. 7. While it aimed to disregard status, this was never completely realised. Ibid., p. 12.

⁶⁵ Poovey, M., *Genres of the credit economy* (Chicago, University of Chicago Press, 2008), p. 31.

took place in these spaces.⁶⁶ Of the discussion that took place through the written records, including the press and printed pamphlets, we have a much clearer picture. Critical reasoning appeared in the printed media from the early eighteenth century onwards, when opinion pieces started to be published alongside the news and “the press was for the first time established as a genuinely critical organ of a public engaged in critical political debate”.⁶⁷ Opinion pieces quickly gained in popularity and by the latter half of the eighteenth century the papers had become larger and had more space, with writers using the newspapers as a platform to discuss diverse economic subjects.⁶⁸ As a result, the reading public became used to debates about economic topics, and thus became familiarised with the workings of the market.⁶⁹ As such, newspapers and other forms of literature mediated between the public and the market by propagating economic ideas, and legitimising opinions.⁷⁰

During periods of shortages, when customary expectations ran up against economic realities and the price-fixing mechanism, these debates raged, in relation to water no less than in relation to grain prices.⁷¹ While no ‘water riots’ have been recorded during the eighteenth century, letters in the public press and pamphlets discussed the way in which access to water was refracted through the market, and touched on issues such as regulation, free competition, and a fair price. These letters are discussed in chapter six of this thesis, and show a deep connection between the functioning of the water market, political ideology, and wider socio-economic concerns.

⁶⁶ Ogborn, *Spaces of modernity*; Glaisyer, N., *The culture of commerce in England, 1660-1720* (London, Royal Historical Society, 2006).

⁶⁷ Habermas, *Structural transformation*, p. 60.

⁶⁸ Black, J., *The English press in the eighteenth century* (London, Croom Helm, 1987), p. 72; Habermas, *Structural transformation*, p. 60; Calhoun, ‘Introduction: Habermas’, p. 9.

⁶⁹ Poovey, *Genres*, p. 31.

⁷⁰ *Ibid.*, p. 2.

⁷¹ Hutchison, *Before Adam Smith*, pp. 11-12.

1.3. Administration and records.

England's development as a fiscal state in the late seventeenth century was accompanied by the rise of administration and bureaucracy.⁷² The Financial Revolution saw an increased volume of transactions, which in turn necessitated a better command of information, as well as control by rules and regulations.⁷³ As ever larger numbers of people became connected by these streams of finances recording all transactions and decisions became more important.⁷⁴ In addition, Enlightenment values fostered an increased interest in recording the natural world.⁷⁵ Together, these trends resulted in a greater availability of data for the eighteenth century, including maps, weather records, as well as financial documents.

The main institutions dealing with London's water during the eighteenth century, namely the water supply companies and the sewer commissions, created a wealth of records as a testament to their administration. The commissioners of sewers were justices and thus part of a legal process, meaning that any meeting of at least six of them counted as a 'court of record', which made binding decisions.⁷⁶ Since their decisions and byelaws carried on beyond the tenure of these commissioners, and were transferred to the next ones, there was a need to record these decisions. But even their day-to-day management needed to be written down: river banks, sewers, and other constructions often slowly deteriorated over long stretches of time, and later commissioners had to know what their predecessors had

⁷² Brewer, *Sinews of power*.

⁷³ North and Weingast, 'Evolution of institutions'.

⁷⁴ Allen, D.W., *The institutional revolution, measurement and the economic emergence of the modern world* (Chicago, University of Chicago Press, 2012), p. 8.

⁷⁵ Golinski, J., *British weather and the climate of Enlightenment* (Chicago, University of Chicago Press, 2007), p. xiii.

⁷⁶ Kennedy, G.G. and Sandars, J.J., *The law of land drainage and sewers* (London, Waterlow Bros and Layton, 1884), p. 49.

decided. In addition, the commissioners needed to know how many people were living in their jurisdictions and how much they should be rated. Therefore, for much of the eighteenth century their actions were recorded, and these records have been preserved.

The water companies had a similar need to record their dealings and decisions: they had to keep lists of their customers and keep track of their water-rents. As administrators of the capital invested in them, they also created a large bureaucracy around their investors: shares were transferred, passed on, and sold. Unfortunately, not many of the companies' records have survived for the eighteenth century: both the records of the New River Company as well as those of London Bridge Waterworks were destroyed in fires that burnt down the headquarters of these companies in 1769 and 1779 respectively. Of the smaller companies, many records have not been left to posterity after they were taken over. Fortunately, much of the information relating to the Chelsea Waterworks has survived from the company's inception in the 1720s onwards. Additional information has been gathered about the companies through newspapers, government administration documents, and the use of maps. The evidence in this thesis has been drawn from a combination of these records.

1.4. Understanding London's waterscape.

By the end of the eighteenth century, the institutions that managed the circulation of London's water had acquired a certain level of prominence. There was a consciousness of the importance of especially the water supply companies, as letters appeared in the public

press regarding the need to protect their infrastructure during the 1780 Gordon riots.⁷⁷ By this time the city mainly relied on the water companies to supply water for use in fire fighting, and their infrastructure became a focal point for London's defence: during the 1798 riots a list of recommendations to defend London was published in *The Times*, and included the protection of London's waterworks and their pipes.⁷⁸ Several of the main water companies were protected by guards during this period of unrest as it was thought that the crowd might attempt to cut the supply in order to let fires in the city burn.⁷⁹

Studying a city's water supply and drainage requires attention to the physical as well as the social worlds within which they were embedded. As such it requires us to consider the geographical conditions and spatial arrangements, as well as the ideological context and economic conditions. The focus of this thesis is on the institutions that managed London's water, and to provide a context for the circumstances in which they were able to become so important to the city. This context is that, as other sources of water were in decline, those in need of it were increasingly distanced from available sources of water. The institutions mediated this distance by means of their infrastructure, and as a result, their management of water through these networks increasingly became the way in which it was circulated.

Both the city's supply and drainage channels are considered as intricate systems with a physical outlay, which was determined by geological, topographical, economic, and social factors. This physical layout in turn influenced the way these systems were organised, necessary technological changes, as well as social interactions with the network. The motives of those in charge of the water supply and drainage networks, as well as those

⁷⁷ *London Chronicle*, 3 June 1780; *London Courant and Westminster Chronicle*, 26 July 1780.

⁷⁸ *The Times*, 25 April 1798.

⁷⁹ LMA/ACC/2558/CH/1/16 Chelsea Waterworks, minutes, 26 April 1798.

using it, influenced where the water was channelled and how the networks were managed, and as a consequence, how water could be accessed.

The thesis begins with an overview of the urban water system, and through a GIS analysis of eighteenth-century maps of London at three separate points in time it is shown how open water gradually disappeared. Increased demand for water resulted in a drop in the water table, while at the same time available water became more polluted by the waste products arising from a greater number of households and industries. As a result, not enough water was available within the densely populated city, while that which was present was of insufficient quality. In addition, the nuisance of polluted and stagnant water in combination with the increased need for building ground in the city, led to the covering of many open water courses.

This set of changes meant that people and households became increasingly distanced from access to water, as fresh water had to be fetched from farther away, and excess water had to be drained through other built-up areas. The need to mediate this distance resulted in a greater role for the institutions that became responsible for this: water companies for the supply, and sewer commissions for the drainage. Both these institutions had to manage infrastructure to bridge ever-increasing distances, as well as to cater for an expanding population. The implications of this increase of scale on a physical as well as an operational level were evident in managerial, financial, infrastructural, and socio-economic changes. The institutions' abilities to cope with the demands of an expanding city form the crux of this thesis, and the core chapters examine several aspects of the strategies adopted in response to the challenges they encountered. Chapter three investigates the history, tasks, and mode of administration of both the sewer commissions as well as the water companies, and

discusses how their managerial structures evolved in response to a greater workload and the need to increase their revenue.

While both institutions faced similar issues — a growing population, an expanding infrastructure, and an increasing workload — they differed in one fundamental way: drainage continued to be managed by the public sewer commissions, while water supply was increasingly handled by commercial companies. This had important implications for the ways in which money could be raised, but also impacted on the manner in which management could be enforced. As it was impossible to prevent drain-water from entering the system, the commissioners of sewers were not able to exclude houses from their network. This, in turn, forced the commissioners to regulate people's usage of the networks, and control their behaviour around sewers. Chapter four focuses on the measures the commissioners undertook to prevent filth building up and blocking flows through the system. The commissions had to face other challenges, too, such as their limited powers to construct new sewers. This problem was solved with the help of private builders and developers who constructed private sewers, which then came under the control of the public commissions. The result was an exceptionally complex hybrid drainage network.

The greater infrastructural requirements of the expanding supply system are addressed in chapter five. This chapter analyses the challenges faced by the water companies, as their networks grew to cover ever-increasing distances between sources and expanding customer bases, and the companies' reactions to such challenges. The most important constraint was the geographical configuration of the companies' points of intake vis-a-vis the locations of their customers, with certain companies having to overcome larger vertical and horizontal distances to supply water. Fluctuations in rainfall, urban growth, technological innovations,

and directors' knowledge thereof, were all important elements in the success or failure of a company's expansion.

Chapter six draws on shifting power relations as a result of the increasing role of private companies in the allocation of water. An analysis of the level of market penetration and the price charged for water demonstrates the increasing reliance of Londoners on a commercial water supply over the course of the eighteenth century. As the companies needed to protect the fixed capital invested in their infrastructure they colluded to keep the price of water artificially high, thus maintaining a steady source of income. The greater importance of the water companies over the course of the eighteenth century and their power to set the price led to public discussions about the market structure and the companies' level of control. As with the grain market, letters and pamphlets were published that discussed the best way of organising the water market, with commentators criticising its monopolistic tendencies while favouring a larger role for free market forces.

Chapter seven returns to the importance of the water companies in times of riot and war. As London came to mainly rely on the water companies for its supply, this meant that the city's emergency supply was in their hands as well. The companies, therefore, had the power to allocate water in times of severe frost and, most importantly, for the purpose of fire fighting. Contrary to their business of selling water, in these instances the companies provided a free supply. Chapter seven discusses the companies' involvement in the provision of the public service, and examines the motivations of the companies' directors as why to supply water for free, touching on the complicated social and economic factors which were involved in creating these arrangements.

Chapter 2. Mapping London's waterscape.

Changes to London's hydrological landscape during the eighteenth century played a formative role in determining how the city's water management developed, and therefore a better understanding of the physical processes and features that constituted this waterscape is important. The presence of water at any particular locality was subject to and part of an interplay of larger biophysical, cultural, and historical processes. Site-specific factors such as ground-type and patterns of urbanisation also influenced how water features were made or altered. Changes over time in any of these processes had implications for the geography of surface water as well as the way it was managed. For these reasons, this chapter examines the impact of the built environment on London's water features over time as well as over space, and draws out the ramifications for the city's waterscape during the eighteenth century.

In order to understand the changes in the physical waterscape, this chapter not only maps out the geography of water features in eighteenth-century London, but also looks in detail at why and how these features were created and altered. In order to do so, it firstly examines the main forces that shaped London's waterscape, namely its surface topography and the expansion of the built environment. Through two case studies it shows how the interaction between topography and urbanisation influenced the spatial arrangements of water features. Secondly, the chapter examines the geography of water over the century by means of an analysis of contemporary cartographic evidence. While there are several limitations to these sources, they allow an assessment of changes in the city's waterscape over time. The results of this exercise show the disappearance of surface water over time,

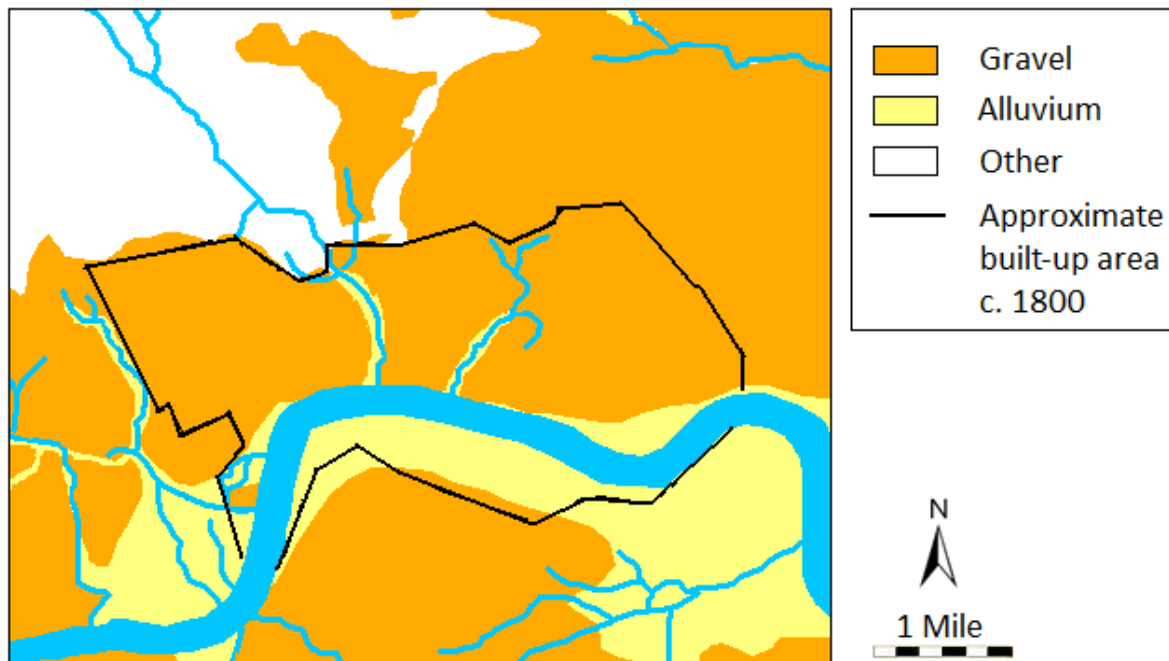
which resulted in an increasing distance between available water supplies and households. The reasons why this distancing occurred were directly related to the expansion of the city, and the effects of this distance had repercussions for understanding the ways in which people interacted with and managed access to water.

2.1. Shaping London's waterscape: topography and urbanisation.

Geology was a significant factor determining the presence or absence of surface water in eighteenth-century London. The city is located in the Thames Basin, formed by a major syncline that extends from the Chiltern Hills to the North Downs, on which lay subsequent strata of chalk, sand, and clay. This underlying bedrock supports the superficial river deposits: mainly brickearth, gravel, and alluvium.¹ These last two deposits in particular played an important part in shaping the geography of London's water features, and their respective locations are shown in figure 2.1, together with the area's 'natural drainage': the original tributaries of the Thames. The extent of the city in 1800 is also shown on this map. The figure shows that most of London north of the Thames was built on gravel deposits, whereas stretches of land south of the Thames and near its tributaries consisted largely of alluvium.

¹ Clout, H.D., *The Times London history atlas* (London, Harper Collins, 1997), p. 16.

Figure 2. 1. London's surface topography in the eighteenth century.



Based on: Geological survey. 'Other' includes sand and brickearth.

The alluvium, which is made up of sands and clay, is poorly drained and much was originally marshland. The gravels and higher sands, on the other hand, allowed surface water to percolate between them, and thus provided a more solid base to build on. London owes its location partly to the fact that the gravels reached close to the river on both sides, whereas downstream the alluvium extended more broadly.² This resulted in the Thames being both narrower and deeper at this location, allowing for a crossing place while remaining open to navigation. Subsequently, the city expanded along the banks of the Thames and was built mainly on gravel. It was only in the nineteenth century that patches of marshy ground in places where there was alluvium were built on, such as Pimlico and a large part of Southwark.³

² Gray, R., *A history of London* (New York, Taplinger, 1978), pp. 21-2; Ellison, R.A., *Geology of London* (Nottingham, Keyworth, 2004), p. ix.

³ Gray, *History of London*, pp. 21-2.

Another advantage of the superior drainage of the gravels was that rain would percolate through it until it reached the layer of impermeable London Clay beneath, where it would form aquifers. Water in these aquifers could either be accessed through a shallow well, or, at locations where the junction between the gravel and clay was exposed near the surface, it emerged as springs.⁴ As a result, the parts of London built on gravel originally had a ready supply of fresh water. There are several reasons why, as the city grew, these reservoirs eventually became insufficient. In the first place, as a result of the expanding population, demand for water exceeded the capacity of the reservoirs, and this, in turn, caused the groundwater level to drop.⁵ As a consequence, wells had to be deepened or enlarged: the well at Clerkenwell, for instance, was enlarged several times in the seventeenth and eighteenth centuries.⁶ Moreover, as the number of private wells multiplied, competition for water increased and it was not unknown for wells to run dry when new ones were sunk in close proximity.⁷

Secondly, population growth resulted in increased water pollution. The substandard quality of the water drawn from London's wells had already been noted in the late Middle Ages.⁸ However, as the city grew, more people meant more latrines, but also more animals, and the waste from both could trickle down into the groundwater. It also meant more industries and noxious activities, each of which came with their own polluting agents.

⁴ Bromehead, C.E.N., 'The influence of its geography on the growth of London', *Geographical Journal*, 60 (1922), pp. 125-35, p. 132; Buchan, S., *The water supply of the county of London from underground sources* (London, Geological Survey, 1938), pp. 12, 15.

⁵ Metropolitan Water Board, *The water supply of London* (London, Staples Press, 1949), p. 32; Sheail, J., 'Underground water abstraction: indirect effects of urbanization on the countryside', *Journal of Historical Geography*, 8 (1982), pp. 395-408, p. 396.

⁶ Weinstein, R., 'New urban demands in early modern London' in R. Porter, ed., *Living and dying in London* (London, Wellcome Institute for the History of Medicine, 1991), pp. 29-40, p. 34.

⁷ *Minutes of evidence taken before the select committee on the supply of water to the metropolis*, PP 1821 (706), p. 70.

⁸ Lewis, D., '"For the poor to drink and the rich to dress their meat": the first London water conduit', *Transactions of the London and Middlesex Archaeological Society*, 55 (2004), pp. 39-68, p. 39.

Finally, as more land was built over, less rainwater was able to penetrate to the gravel whilst at the same time sewers channelled it straight to the river.⁹ In certain places, where the gravel extended to a depth below the level of the Thames, brackish river water flowed against its natural drainage and replaced rain water, turning wells near the river impotable.¹⁰ The expansion of the built-up area of the city therefore had an important impact on fresh groundwater; surface water on the other hand was subject to a more subtle interaction of topography and social geography.

Over the eighteenth century, the social differentiation of certain areas of London became more apparent, and this, too, had an impact on the city's waterscape.¹¹ By the mid-eighteenth century, the City of London chiefly housed the buildings of financial institutions such as the banks, exchanges, and the great joint stock companies, as well as small tradesmen, their wholesale establishments, and markets. The area surrounding the City had a more industrial character: small, twisting lanes and alleys housed artisans that specialised in different trades, depending on the area. The metal trades, clock making, and jewellery making were located north of the City, in Clerkenwell. To the east was the silkweaving district of Spitalfields, while the riverside housed a myriad of industries that relied in one way or another on the Thames. These included trades related to the shipping industry, such as rope-making, boat-builders, and docks, but also included activities that needed access to a waterway, either to use the water as a raw material, or for the disposal of their waste. These industries included sugar refineries, as well as oil-, colour-, and soap-works. A similar

⁹ Buchan, *Water supply*, p. 15.

¹⁰ Ibid., pp. 15, 16.

¹¹ Spate, O.H.K., 'The growth of London, A.D. 1660-1800', in H.C. Darby, ed., *An historical geography of England before A.D. 1800* (Cambridge, Cambridge University Press, 1936), pp. 529-48, p. 534.

district emerged on the south side of the Thames in Rotherhithe, while in Southwark the main industry was tanning, with its associated trades of fell-mongering and wool-stapling.¹²

The area west of the City, meanwhile, had a very different character. The West End became a fashionable area after the City's destruction in the Great Fire of 1666 and the restoration of the monarchy, which attracted many aristocrats and moneyed gentlemen to take part in Court life or deal in government, and firmly consolidated its position as the residential district of London's social elite during the eighteenth century. Its streets were more spacious and light, and as the area was mainly upriver and upwind from the noxious trades surrounding the City, the living environment was better. In addition, the London season of entertainment and social pleasures that flourished during the eighteenth century was mainly situated in the western part of town and attracted many people of high social standing to the capital.¹³

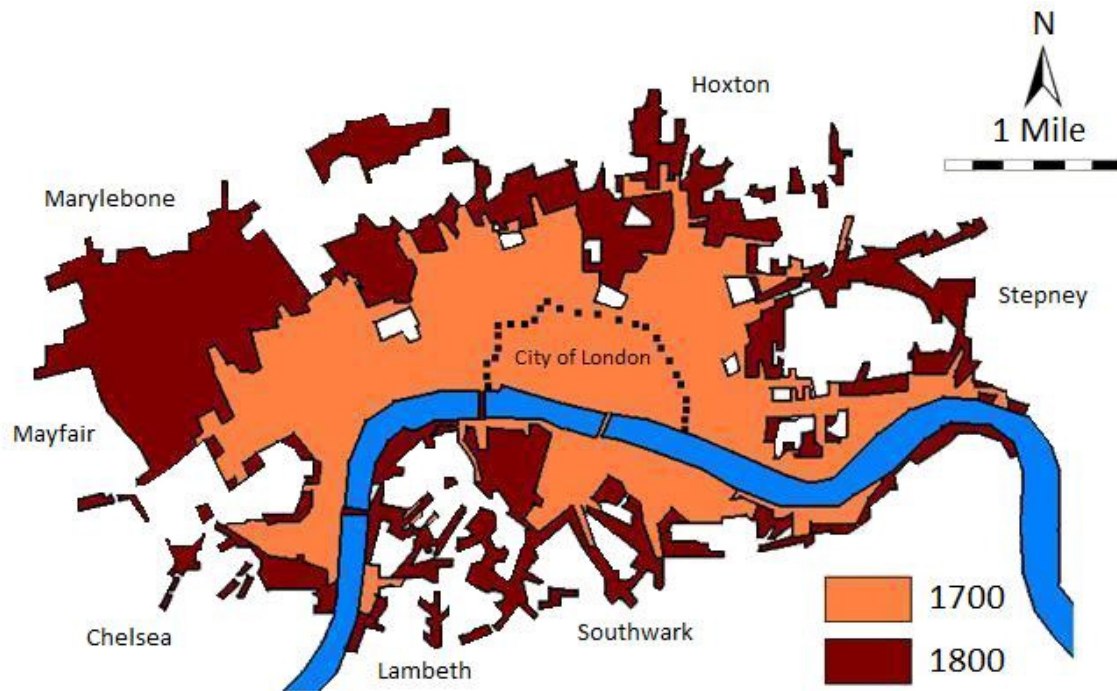
The increased demand for fashionable residences fuelled a spectacular growth in the number of houses in the West End. The expansion of London between 1700 and 1800 can be seen in figure 2.2. The West End stands out as a large, continuous development, whereas many of the newer neighbourhoods to the east and south of the capital were built more piecemeal in a pattern of ribbon development. This distinction was mainly a reflection of landownership. The land to the west of London was owned by fewer large estates which were planned and developed in a continuous and uniform manner by their owners, whereas landownership elsewhere was more fragmented and buildings were erected unplanned

¹² Spate, 'Growth of London', pp. 534-5.

¹³ Inwood, S., *A history of London* (Basingstoke, Papermac, 2000), p. 252.

along the roads.¹⁴ The open spaces between the buildings were used to spread out drying clothes and tans, as well as for market gardening.

Figure 2. 2. The physical expansion of London during the eighteenth century.



The impact of both ground and land-use on the geography of London's waterscape can be shown by examining the water features of two contrasting localities. The first, Southwark, is built on alluvium and has an industrial character. Figure 2.3 shows a section of the Christchurch parish in south London as depicted on the 1746 Rocque map of London.¹⁵ Open water is evident in this area: in the centre below is a marshy piece of land, indicative of the poor drainage of the alluvium. Open sewers along the streets point to the same issue. Several features depicted on this map indicate the presence of tanners: the tentergrounds

¹⁴ Inwood, *History of London*, p. 258.

¹⁵ Rocque, J., *A Plan of the Cities of London and Westminster, and Borough of Southwark; with the Contiguous Buildings; From an actual Survey, taken by John Rocque, Land Surveyor, and Engraved by John Pine, Bluemantle Pursuivant of Arms, and Chief Engraver of Seals, &c To His Majesty* (London, 1746). Hereafter: Rocque map. No. 96 in Howgego, J., *Printed maps of London, circa 1553-1850* (Folkestone, Dawson, 1978). Scale: 26 inch to the mile.

to the north and south of the marshland were used to pen out their hides, while the surrounding ponds where the leather was soaked and treated are depicted as well. To the north, in the top centre of the image, is a garden with visible water courses. Other industries are also evident in this area: a skin market and a vinegar yard are depicted as well as a whitening ground and a brewhouse. The natural presence of water here catered for trades that needed the water. However, the noise and pollution these industries created — tanneries made use of ingredients such as lime, urine, dung, and fermenting rye — gave areas like these a distinctly industrial character, inhabited mainly by poorer artisans.¹⁶

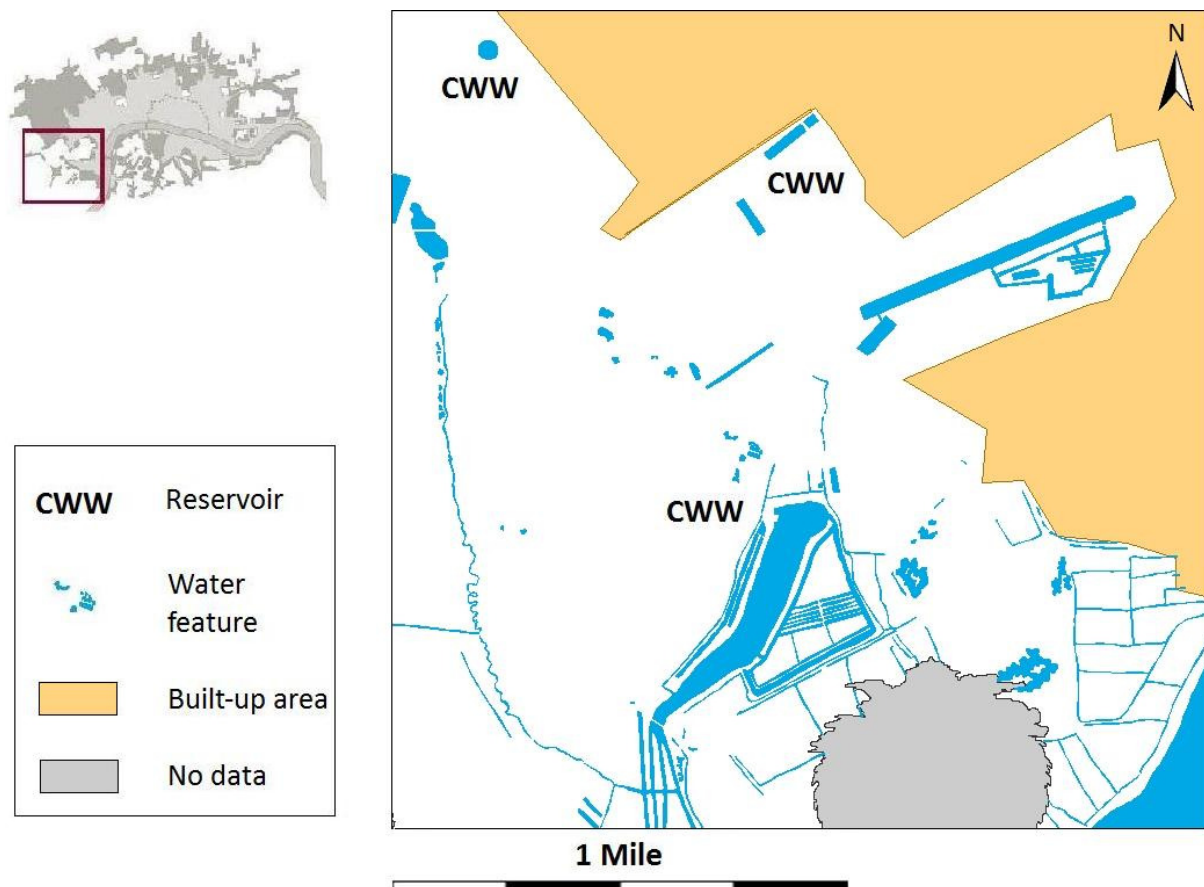
Figure 2. 3. Christchurch on the 1746 Rocque map with water features highlighted.



¹⁶ For the nuisances associated with the tanning process see Jørgensen, D., 'Local government responses to urban river pollution in late medieval England', *Water History*, 2 (2010), pp. 35-52, pp. 38-9.

The waterscape in the west of town looks profoundly different from that of Southwark. Figure 2.4 is based on the same Rocque map of 1746, and depicts the edge of the West End. In contrast to Southwark, there are no water features visible between the built-up area. Instead, the only water in this image was located in the fields around the city. In addition, the water features here were of a very different nature to those in Southwark, and reflected the different function of the area: that of grand houses rather than industry.

Figure 2. 4. West End water features as depicted on the 1746 Rocque map.



The largest water feature on figure 2.4 is the reservoir of Chelsea Waterworks (CWW). This was a company supplying piped water to the inhabitants of Westminster and the West End, which also owned several other reservoirs closer to the built-up area, as indicated on

the map. The presence of this water company here can be explained by several factors. As there was no open water present near households, and as the demand from the increase in population had exceeded the capacity to draw water from wells sunk into the ground, inhabitants had to obtain their supply from elsewhere. The Chelsea company provided a convenient way of having it laid into people's houses and the residents of this area were wealthy enough to pay for this service. The infrastructure used by the company also had an aesthetic function: originally the smaller reservoirs in the park had been ornamental ponds, and the company had been allowed to make use of them as long as they were kept in an attractive style.¹⁷ Other ornamental features in this area included the royal canals and the Serpentine, which was created from the Westbourne, a natural tributary of the Thames. The company's ponds, which had previously been used to attract ducks and deer for the personal pleasure of the King, became part of the landscape that the West End residents used for fashionable promenading as the parks opened for the public.

The case studies of Southwark and the West End show how water features reflected the surface topography as well as specific land-use patterns of each area. The features were hybrid mixes of naturally occurring material and man-made constructions that changed according to alterations in their environment. Shifts in land-use, for example through the process of urbanisation, therefore impacted on the way water was used, and water features were restructured to reflect this.

¹⁷ LMA/ACC/2558/CH/1/1 Chelsea Waterworks, minutes, Aug. 1725.

2.2. Mapping London's water features.

In order to assess the nature of London's waterscape, several sources of evidence can be considered. Two main conditions have been taken into account: the sources should be as precise, and as complete as possible. While images and descriptions can be useful in providing detail, they are often localised and therefore too limited to provide an overview of London as a whole. For this reason, the analyses in this chapter rely on cartographic evidence from which it is possible to reconstruct the spatial patterns of water courses and drainage channels on a larger scale. In order to arrive at any meaningful results, however, it is necessary to understand the mapping techniques and conventions of the time. While eighteenth-century maps were not yet based on triangulation, they nevertheless improved in accuracy from the pictorial maps of earlier periods.¹⁸ From this time, therefore, despite the inaccuracies that still existed, it becomes possible to explore more precisely the geography of London's waterscapes.

London's rapid expansion during the eighteenth century offered the incentive to create new maps at regular intervals which can provide a basis on which to assess changes that took place over time. However, map surveying was a time-consuming and expensive business, and most maps produced in the first half of the eighteenth century were updated versions of earlier maps.¹⁹ The accuracy of the updates varied widely: newly engraved maps were often based on earlier surveys, and even a relatively reliable cartographer such as John

¹⁸ Thomas Milne's 1800 map was the first published London map based on triangulation. Howgego, *Printed maps*, p. 24.

¹⁹ The most important maps of the early half of the eighteenth century were based on the Morgan map. including Morden and Lea (1700), Henry Overton (1720) and George Foster (1738). Strype's 1720 survey even shows the ostrich. Hyde, R., 'William Morgan's survey of London, 1682', in *Facsimile of London &c Actually surveyed* (London, Harry Margary, 1977).

Cary would rather update his old maps than make a new survey. This process would often consist of making additions to the original map rather than a complete review, and for this reason it is important to only examine first editions of newly surveyed maps, so that the highest degree of accuracy can be achieved.²⁰ James Howgego's seminal survey of London maps included over 400 separate maps for the period 1553 to 1850, but only a few of these stand out as original surveys, which are the most accurate cartographic sources available for London.²¹

Three maps depicting London between about 1680 and 1800 have been selected based on these criteria and can be used to explore changes in London's waterscape: the 1682 Morgan map, the 1746 Rocque map and the 1792-9 Horwood map.²² This last map was chosen over another original survey, the 1787 Cary map, for several reasons. Firstly, Horwood map's scale was more detailed; secondly, it was surveyed closer to the end of the century, before the early 1800s' alterations in the waterscape by the canals and docks; and thirdly, corroborating evidence of water features could be sought from the 1797 Stockdale map.²³

The 1682 Morgan map is considered to be the first truly modern map of London. It was conceived as a ground plan, although it does include some pictorial representations of important buildings, such as churches. It was based on earlier separate surveys of the City of

²⁰ Howgego, *Printed maps*, p. 37.

²¹ *Ibid.*

²² Morgan, W., *London &c Actually surveyed* (London, 1682). Hereafter: Morgan map or Morgan 1682 map. Not to be confused with the Morgan/Ogilby map of 1680 that only covered the City of London, albeit in larger scale. No. 33 in Howgego, *Printed maps*. Scale: 17 inch to the mile; Horwood, R., *Plan of the Cities of London and Westminster and the Borough of Southwark and Parts adjoining, Shewing every House. By R. Horwood* (London, 1792-9). Hereafter: Horwood map. No. 200 in Howgego, *Printed maps*. Scale: 26 inches to the mile.

²³ Stockdale, J., *A New Plan of London, XXIX Miles in Circumference; engraved by S.J. Neele* (London, 1797). Hereafter: Stockdale map. No. 213 in Howgego, *Printed maps*. Scale: 6 ½ inch to the mile. This map is the most accurate on water features from the 32 maps listed in Howgego made in the 1790s. Many sewers and wells have been labelled.

London, Westminster, and Southwark in the 1670s, which were supposed to be published each in their own right. However, William Morgan realised that as the poorer Southwark residents could not afford to buy their map, he could not make a profit selling them separately, and as a result he decided to combine them into one map. Although this large map was based on the earlier surveys, it seems clear that some additional work was carried out. The map shows streets that were not named until 1681, and the ostriches gifted to King Charles II in January 1682 were depicted in St James Park.²⁴

The next complete survey was undertaken during the early 1740s by John Rocque, which resulted in his 1746 map of London. Rocque was trained as a *dessinateur de jardins*, someone who measured and drew estates for landowners. His background is evident in the precise way in which he depicted parks and fields around the capital, often differentiating land-uses.²⁵ Rocque had indicated that the neighbouring country should be drawn in detail on the map, rather than be filled up with ornaments and dedications, as was the case on Morgan's map.²⁶ The map is completely ichnographical: the only things drawn pictorially were trees in fields and ships on the river.²⁷ A 1740 proposal for the map indicated that the survey was begun in 1738.²⁸ By 1746 a draft was completed and people were invited to come and check its accuracy. In addition, Rocque sent out men, each with a portion of the map, to check whether it still matched the survey.²⁹ The map that was published based on these quality checks was therefore as accurate a representation of London in 1746 as possible. In the same way as the Morgan map had been updated for the previous 60 years,

²⁴ Glanville, P., *London in Maps* (London, The Connoisseur, 1972), p. 28; Hyde, 'William Morgan's survey'.

²⁵ Foxell, S., *Mapping London: making sense of the city* (London, Black Dog Publishing, 2007), p. 31.

²⁶ Hyde, R., 'Portraying London mid-century — John Rocque and the brothers Buck', in S. O'Connell, ed., *London 1753* (London, British Museum Press, 2003), pp. 30-1.

²⁷ Hyde, R., 'The making of John Rocque's map', in *The A to Z of Georgian London* (Lymington, Harry Margary, 1982), pp. v-viii, p. vii.

²⁸ Hyde, 'Portraying London', p. 29.

²⁹ *Ibid.*, p. 32.

the Rocque map became the base which later mapmakers would update during the second half of the eighteenth century. However, London expanded greatly over the next decades, and by the end of the century the need for a new survey arose.

Two main cartographers produced new surveys towards the end of the century: John Cary and Richard Horwood. Cary's map was first published in 1787 and was a different sort of map than the ones published before that date: it was a map to be used rather than to be displayed.³⁰ Richard Horwood's 1792-9 map was the largest and most ambitious London map made up to that date. It consisted of 32 sheets, each one of which was published individually over the course of eight years.³¹ Horwood had been working for the Phoenix Fire Insurance Company as a surveyor before he started the project, and as a result he perceived the need for a map with a high degree of accuracy. The aim was to show every house in London individually, a goal which Horwood eventually achieved.³² Howgego has described this map as the "most important London map of the eighteenth century" and it remained the most accurate map of London until that made by the Ordnance Survey 50 years later.³³

All three maps discussed above depict the built-up area of London at the time, which included the City of London, the City of Westminster, and the borough of Southwark, as well as new developments on the outskirts. Whereas it could be argued that local, larger scale maps of particular areas provide more detailed information about water features, maps that

³⁰ Cary, J., *Cary's New and Accurate Plan of London and Westminster, the Borough of Southwark and parts adjacent* (London, 1787). No. 184 in Howgego, *Printed maps*. Scale: 6 ½ inch to the mile; Foxell, *Mapping London*, p. 35.

³¹ Sheet B2 (Mayfair) was published in 1792, B1 (Fitzroy Square) in 1793. A1 to 4 (Marylebone, Paddington, and down to Chelsea) were published in 1794, and B3 and B4 (St Martin-in-the-Fields and Chelsea Waterworks respectively) in 1795. The rest of the map was published in 1799. Laxton, P., 'Richard Horwood's map and the face of London, 1799-1819', in *The A to Z of Regency London* (London, Harry Margary, 1985), pp. v-xiv, p. vi.

³² Laxton, 'Richard Horwood's map', p. v.

³³ Foxell, *Mapping London*, p. 36; Howgego, *Printed maps*, p. 21.

cover London and its environs were chosen with the aim of depicting the city's total waterscape. Although using maps in this way might result in a loss of spatial resolution, nevertheless, assuming consistency within each one, they provide a uniform basis for comparison across the entire built-up area.

While maps are graphic representations of some aspects of the real world, even modern cartography is by no means a wholly factual science, and it cannot be assumed that what is depicted on the map is necessarily or unproblematically a true reflection of a geographic reality. Maps, like all historical documents, should be evaluated in the context of their creation, taking into account issues of power and purpose together with existing cartographic knowledge and practice.³⁴ Mapmaking was an expensive business, and the creators of these large maps had to look for funding throughout the surveying and publishing process. Their main sponsor often influenced whether and in which shape the map was eventually published. Morgan filled up most of the space around the built-up area on his map with dedications to the King, Lord Mayor and various livery companies that sponsored him, all of which were honoured by being shown in pictorial form. Rocque had a specific agenda in making his map: to prove that London was as large as Paris, and just as beautiful. His map shows the new squares of the West End in clean, straight lines, broadcasting its modernity, while it shows the area around Covent Garden, which was in fact deteriorating into a slum by then, in much the same way.³⁵ Horwood had applied for public funding but failed to obtain it, and was supported by the Phoenix Fire Insurance Company instead. This company had an interest in the project as a precise map would make

³⁴ Harley, J.B., *The new nature of maps: essays in the history of cartography* (London, Johns Hopkins University Press, 2001), pp. 35-44.

³⁵ *Ibid.*, p. 69.

it easier to identify the exact location of their clients.³⁶ Each map, therefore, needs to be understood in its specific context rather than treated as an isolated example that reflects a geographical reality at the time of its making.

The cartographers' backgrounds and experience also influenced what would be included on the map, which has several consequences for the ways in which natural features, and in the case of this study, water, was represented. Rocque, the former landscaper, showed the most detail: trees, streams, and animals are all meticulously displayed. As he included the fields around London in his survey, water features such as rivers, marshes, and pools were also incorporated. Several scholars have noted the presence of water on Rocque's map, among them Philippa Glanville, and Felix Barker and Peter Jackson.³⁷ Morgan showed natural elements in detail as well, such as the animals in St James Park, and displayed water in fields and sewers alongside roads. However, as he focused on the built-up area, most of the surrounding space was taken up by dedications and plates, ignoring the natural spaces that undoubtedly existed at the time.

Horwood showed the fewest and least detailed natural features. His focus was primarily on streets and houses, and natural features were depicted according to their function rather than their form. For example, he chose to depict the Fleet River, which functioned as a parish boundary, only as a border and not as a water feature, even though the New River was drawn as a river on the same map sheet. By omission, the Horwood map focused more on the human than on the natural world. Cary's 1787 map did not include much detail on

³⁶ Laxton, 'Richard Horwood's map', p. vi.

³⁷ Glanville, *London in maps*; Barker, F. and Jackson, P., *The history of London in maps* (London, Barrie and Jenkins, 1990).

natural features either.³⁸ Cary had previously made road-maps and his London map reflected this: outside the built-up area it only showed some tracks and byways.³⁹

The exclusion of natural features poses a challenge when using the maps as a source for identifying water features. In order to mitigate this problem, corroborating evidence has been sought from the Stockdale map. This map, even though its scale was much smaller, depicted a far larger number of water features. Figure 2.5, for example, compares the Horwood and Stockdale maps for the section that shows part of Bermondsey, at the time of survey on the urban fringe. Unfortunately not much is known about the origin of the Stockdale map, and it is therefore difficult to ascertain whether it was based on an original survey. In order to check its accuracy, the map has been carefully compared with Horwood's map in relation to features which appear on both maps. In addition, two maps from the British Library's Crace collection, showing the countryside around Marylebone and St Pancras in the 1790s, have been examined for water features as well.⁴⁰ It was found that they depicted a similar amount of water-filled gravel pits as the Stockdale map shows for this area, whereas Horwood showed none. Having ascertained that the Stockdale map accurately represents London at the end of the eighteenth century, water features only present on the Stockdale map have been included in the analysis. In addition, while the Horwood map is considered to be one of the most accurate maps in terms of housing and street development, and used as a source for the analysis of these aspects, it has to be recognised that it has its limitations in regard to natural features.

³⁸ Foxell, *Mapping London*, p. 35.

³⁹ Fordham, H.G., *John Cary — engraver, map, chart, and print-seller and globe-maker, 1754 to 1835* (Cambridge, Cambridge University Press, 1925), pp. xiv-xv; Foxell, *Mapping London*, p. 35.

⁴⁰ Richardson, *Large plan of an estate called the Marylebone Park Farm*, BL/Crace/XIV/28; Thompson, *Large plan in two sheets of the Parish of St. Pancras*, BL/Crace/XIV/43.

Figure 2. 5. Comparison of Bermondsey area on Horwood (left) and Stockdale (right) maps.



In addition, there were several practical issues regarding the depiction of water on a map. Contrasting definitions of water played a role in explaining the differences in its depiction. For example, at what point does a ditch which has a seasonal flow of water stop being identified as a ditch and start being depicted as a small stream? The seasonality of surveying also played a role: summer levels of water in ditches and sewers would have been different from winter levels, and depending on the season in which a part of the survey was undertaken, this could be reflected on the map.⁴¹ When a watercourse was depicted, the issue of ‘fuzzy boundaries’ could also arise. The Thames was tidal with sloping banks and it was therefore up to the mapmaker to decide where to draw the boundaries of the river.⁴²

⁴¹ Gurnell, A.M., Peiry, J.-L., and Petts, G.E., 'Using historical data in fluvial geomorphology', in M. Kondolf and H. Piégay, eds., *Tools in geomorphology* (London, Wiley, 2003), pp. 77-103, p. 94.

⁴² *Ibid.*, p. 93.

These variations mean that none of the maps can be taken at face-value for the purposes of comparison. However, used with caution, the maps outlined above include some of the best cartographic resources available for the study of eighteenth-century London, and in terms of accuracy and scale they are unrivalled. In order to examine London's water features they provide the best possible overview and provide enough consistency to establish the characteristics of the waterscape at a given time.

2.3. London's changing waterscape.

For the analysis of London's waterscape all water features on digitised versions of the three maps were traced as separate layers, which are presented in figures 2.6, 2.7, and 2.8. For the various reasons discussed above, it is not possible to directly compare these figures to each other. However, by looking at the waterscape at three points in time it is possible to draw some tentative conclusions about changes that took place over the course of more than a hundred years. The most obvious change the comparison of the three images shows is the growth of the built-up area. While in 1682 the built-up area was still confined to areas near the Thames, by the late eighteenth century new developments had spread west and north, and filled up previously open spaces. The second change is that the later maps show a diminishing amount of linear water features, especially south of the Thames. This is particularly noticeable between the Rocque and the Horwood/Stockdale maps. These features were mainly structures that were part of London's drainage system, and their gradual disappearance is directly related to the expansion of the built-up area.

Figure 2. 6. Water features on the 1682 Morgan map.

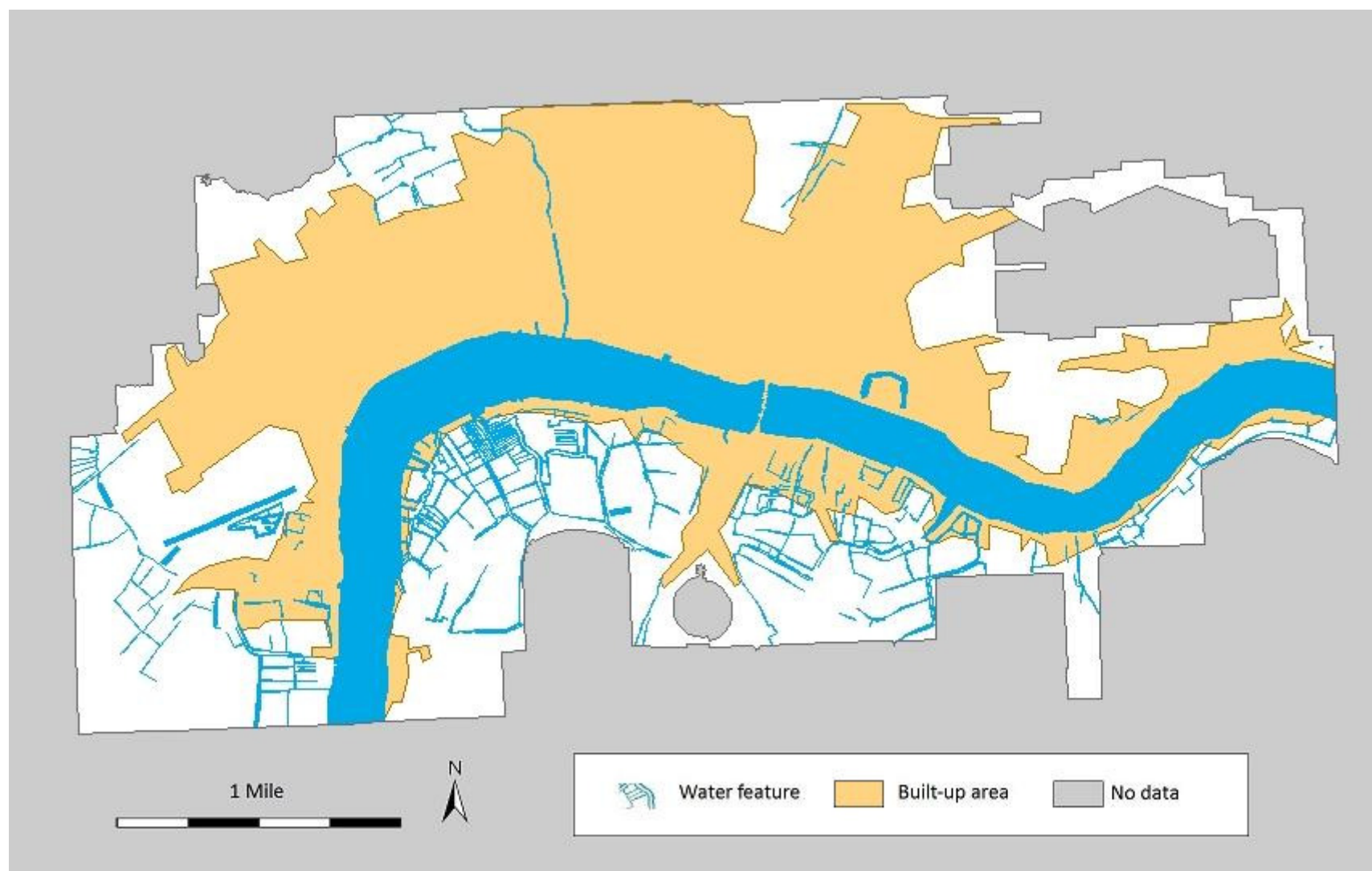


Figure 2. 7. Water features on the 1746 Rocque map.

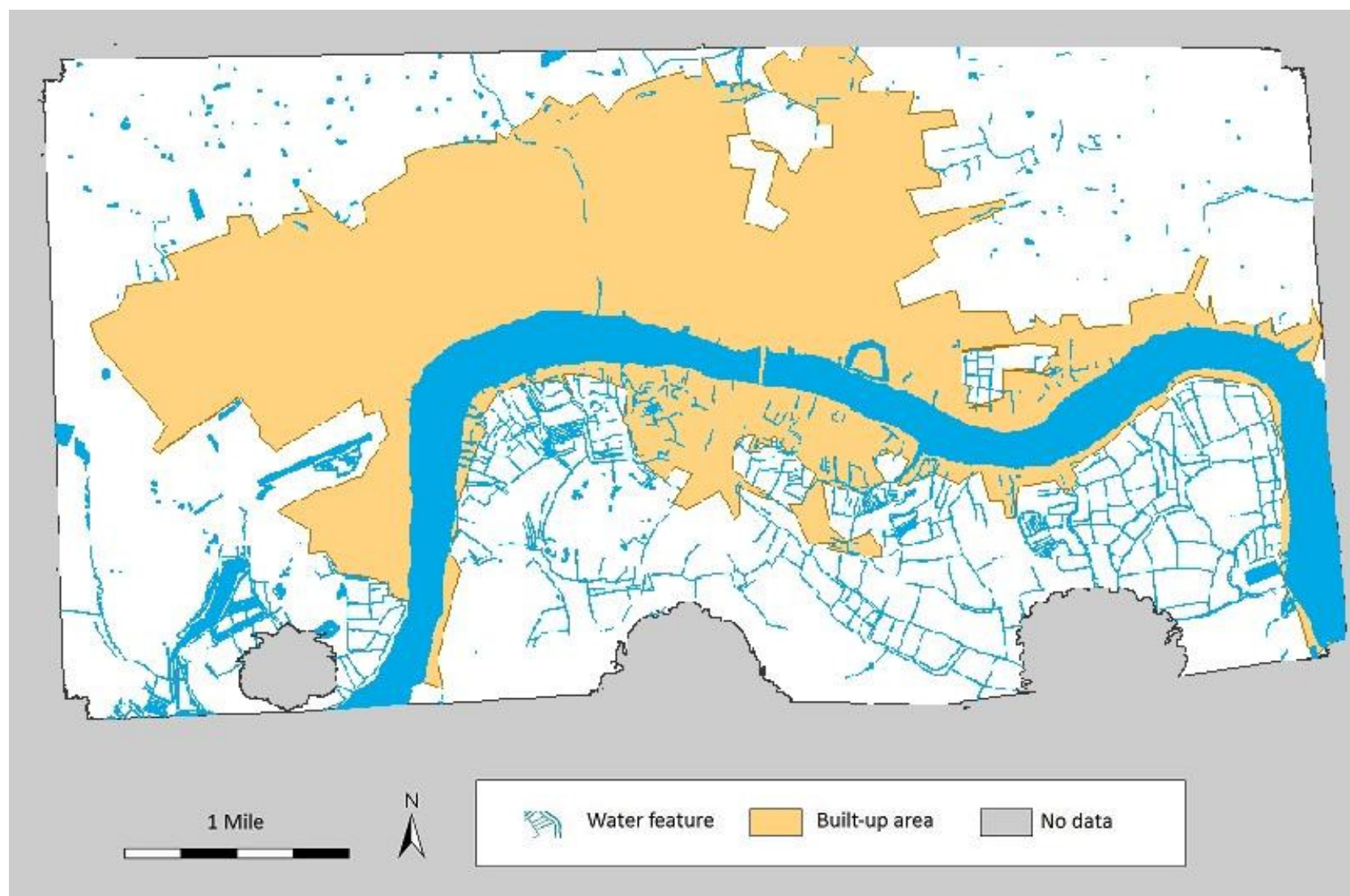
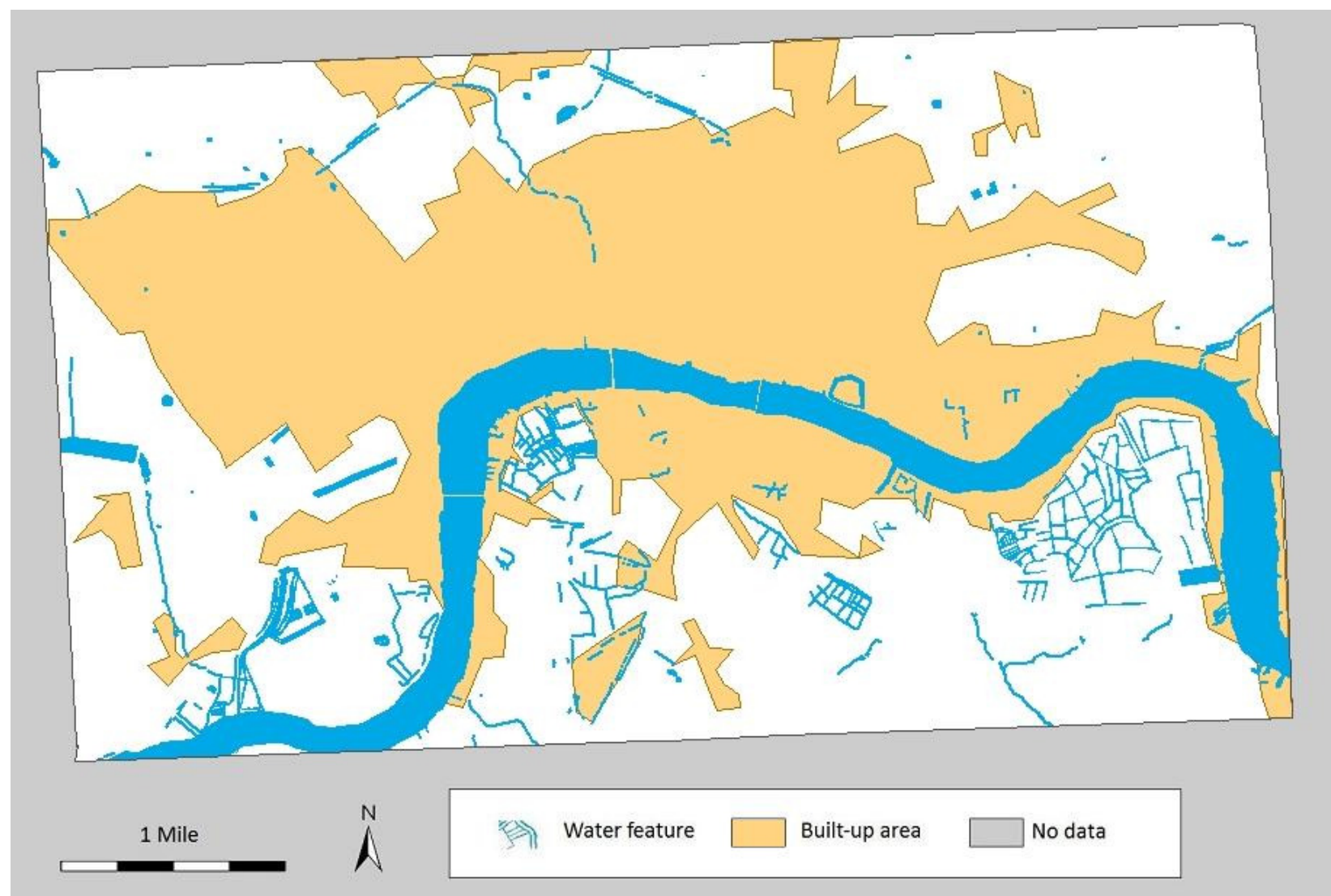


Figure 2. 8. Water features on the 1792-99 Horwood map combined with the 1797 Stockdale map. Extent based on Horwood.



The process of urbanisation involves both a reduction in ground infiltration as a result of built-up surfaces as well as larger quantities of runoff, due to the levelling of the surface. In addition, the urban environment brings the construction of a man-made drainage system with it, which implies new routes for the water at increased speeds.⁴³ The drainage structure in eighteenth-century London started with 'kennels', gutter-like open channels in the streets that led to the sewers. Figure 2.9 is a contemporary engraving showing a single kennel running down the centre of Fenchurch Street in the mid-eighteenth century. Other streets had double kennels, one on each side of the road. As the water drained from the kennels into the sewers it was filtered through grates, leaving any solid waste to be collected.

Figure 2. 9. View of Ironmongers' Hall, c. 1753.



Anonymous. Source: © Trustees of the British Museum.

⁴³ Akan, A.O. and Houghtalen, R.J., *Urban hydrology, hydraulics, and stormwater quality* (London, Wiley, 2003), p.1.

It is an important distinction that in the eighteenth century a sewer mainly implied a 'drainage channel' rather than the later definition of a wastewater removal channel. A 1732 treatise on *The Laws of Sewers* defined a sewer as "a fresh Water Trench, or little River, encompass'd with Banks on both sides", which was distinguished from a ditch by having a constant current in it.⁴⁴ Sewers were meant only to channel excess rainwater, and as the 1732 definition 'little river' implies, they were not very different from the natural streams that drained London in ancient times. In fact, the urbanised parts of the Thames' tributaries were treated as sewers; the river Fleet, for example, was labelled "Fleet sewer" on the Stockdale map.

The sewer network was managed by the sewer commissions, of which there were several, each one governing a particular area. Residents who wanted to make changes to the sewers had to apply to their local commission, which would generally allow them to make an alteration. Their consent was based on certain conditions, usually related to the size and material used, as well as impact on other residents. If one were to make alterations without informing the local commission, and this was discovered, the commissioners fined the offender and ordered the sewer to be restored to its previous state. However, if the changes in the network actually would have been allowed under the aforementioned conditions, and a subsequent application was made requesting permission for the alterations to remain, most commissions tended to allow the changes to stand, and waived the fine. From the commissions' records, therefore, it is possible to gain an understanding of how changes in the network took place, and why, as they include both alterations that were

⁴⁴ Hargrave, F., *The laws of sewers* (London, 1732), pp. 25-6. Strictly speaking a gutter was private and a sewer public, but usually gutters were called sewers as well. Woolrych, H.W., *A treatise on the law of waters, and of sewers* (London, Saunders and Benning, 1830), p. 346.

made through the official institutions as well as alterations that were ‘illegally’ made, and found out.

The area where most change took place, as shown in figures 2.6 to 2.8, was under the jurisdiction of the Surrey and Kent Commissioners of Sewers. They administered a particularly marshy area: on all three maps, most surface water was located south of the Thames and approximately 83% of surface water can be found south of a line that bisects the Tower of London.⁴⁵ As discussed above, much of southern London was built on a layer of alluvium, which did not drain surface water away easily, and thus, many sewers had to be created to channel the water. Southwark was also an area that underwent intense urbanisation in the eighteenth century, especially after the completion of Westminster and Blackfriars Bridges in 1750 and 1769 respectively, which improved access to Westminster and the West End. Through the records of the Surrey and Kent Commissioners of Sewers it is possible to see how the growth of housing and population impacted on the area’s waterways.

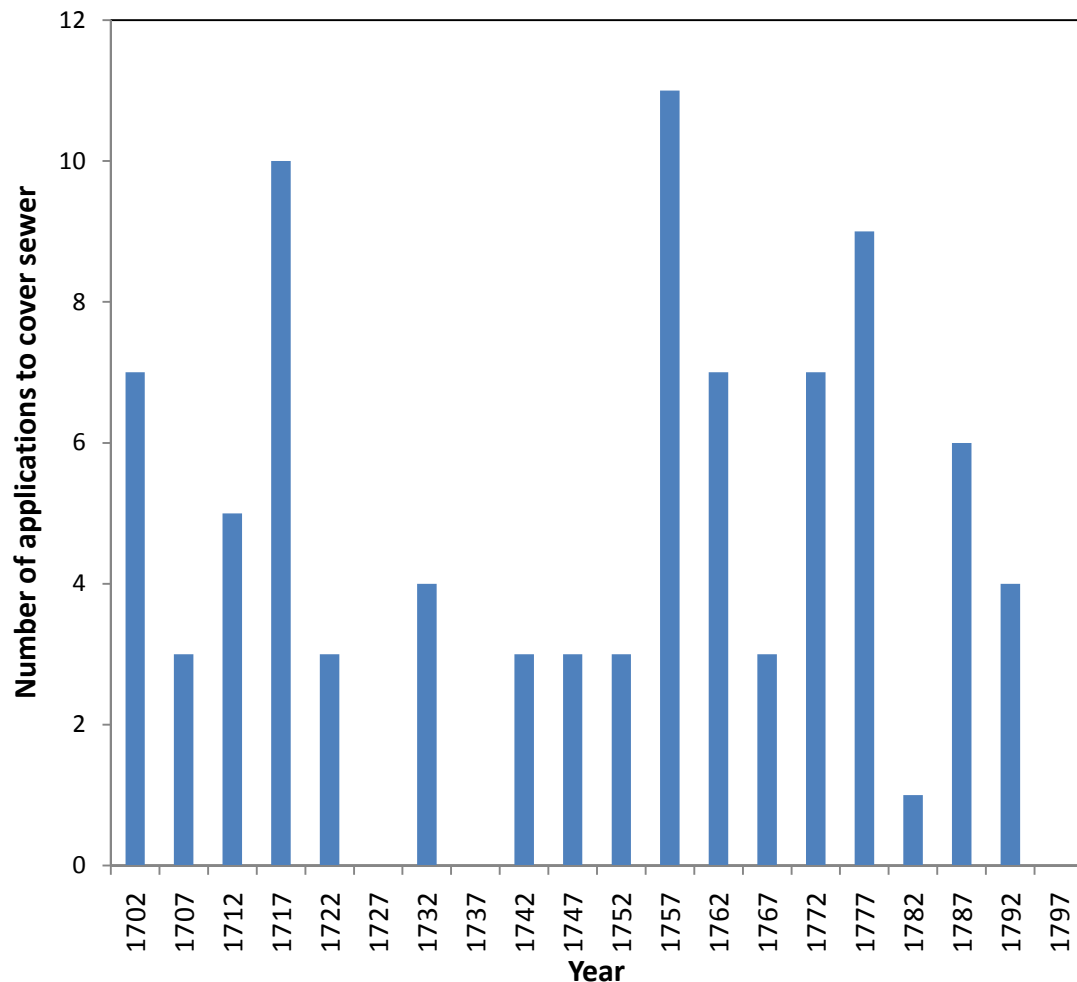
Figure 2.10 shows the number of applications to cover a sewer found in a sample of the meetings of the Surrey and Kent Commissioners of Sewers between 1702 and 1797.⁴⁶ These were applications to either stop up a sewer by filling it in, in which case sometimes alternative drainage had to be found, or to arch over a sewer, in which case the commission stipulated the space that the water had to be allowed. The data in figure 2.10 include sewers that were found to have been (illegally) covered and were allowed to be kept that way in the sampled year, but does not include those that were ordered to be restored to

⁴⁵ On the Rocque map, not including the Thames. This includes surface water in Chelsea and Pimlico.

⁴⁶ Because of the large quantity of data, only two years from every decade have been included in the sample: those ending in -2 and -7.

their original state. The length of sewer applied to be covered could vary from just a few yards to the whole length of a street.

Figure 2. 10. Applications to cover sewers in the Surrey and Kent commission's territory.



Source: Minutes of the Surrey and Kent Commissioners of Sewers, LMA/SKCS/42-56.

It becomes obvious from this figure that the covering of sewers was a regular occurrence, which picked up between the 1750s and 1770s, when many new roads and developments were laid out as a result of the increased access to the south bank. The Surrey and Kent commission was not a permanently standing committee, and the number of meetings in each year varied. For example, in the late 1720s and 1730s some of the sampled years fell in

a period in which the commission only met to be sworn in and discuss financial issues, and did not record any other activity, while in other years they met every month and a full record of the meetings is available. It is therefore likely that more sewers were covered in the years for which there are no full records, as it was noted that people were fined, but not whether it was for covering a sewer or something else. While the records do not mention the exact location of each covering application, most of the ones that are known fall into the area shown on the Rocque and Horwood maps.

The reasons why the sewers were covered were complex, but ultimately a result of the increase in urbanisation. Mainly people wanted to cover the water because it was overused. Until 1815 it was illegal to dump any household waste or effluent into the sewers, although this practice happened fairly regularly. Solid waste, theoretically at least, was to be collected in cesspools and laystalls. Solids mixed with the water in the streets were supposed to be filtered out by the grates, and so would not be able to block up the flow in the sewers. In practice, however, the sewers had many different functions, ranging from domestic and industrial water supply, a source of power, washing, as well as waste disposal. In urban areas, the close proximity and concentration of people and different activities frequently led to uses of the sewer system that were incompatible with its drainage function.

The various sewer commissions in London, including the Surrey and Kent commission, spent the majority of their time ensuring that sewers could flow freely and were not blocked by solid waste. Their records show that the keeping of animals often posed problems, especially pigs, which were described as a “common nuisance” in 1742.⁴⁷ Most complaints were resolved by the accused animal-keeper proving he had a grate to filter out solid waste,

⁴⁷ See several cases in LMA/HFCS/17 Holborn and Finsbury Commissioners of Sewers, minutes, 5 Nov. 1742.

or promising to make one.⁴⁸ People were accused of sweeping dirt into the sewers as well. In addition, all commissions tried to prevent people from connecting their toilets to the sewers, with varying degrees of success.⁴⁹ Many industries were guilty of draining their wastewater into the sewers.⁵⁰

But while the commissioners generally concerned themselves with the issue of preventing solids entering the sewer network, the general public was also concerned with issues of foulness and stench that could arise from the open sewers. In 1757 there were several examples of the Surrey and Kent Commissioners of Sewers allowing people to fill up a sewer after they complained that their local sewers were very foul and caused a public nuisance.⁵¹ Across the capital there were cases of people applying for sewers that contained particularly offensive smelling water to be covered. For example, inhabitants of King Street, St Margaret Westminster, were greatly annoyed by a cook shop from which “cabbage water and other offensive water” drained into a kennel above ground. The inhabitants believed that this smell endangered their health, and requested that the water be diverted underground into a sewer.⁵² This was not an isolated case: markets, slaughterhouses, and other activities producing foul-smelling waste generated similar complaints.⁵³

In instances like these, where the problem could not be solved by filtering the water, the suggested solution was to cover the sewer and thus hide the water underground. It follows that the commissions were at this time unable to prevent people from using the sewers for

⁴⁸ See e.g. LMA/SKCS/44 Surrey and Kent Commissioners of Sewers, minutes, 21 March 1731/2 and 20 June 1732.

⁴⁹ E.g. LMA/HFCS/16 Holborn and Finsbury Commissioners of Sewers, minutes, 28 April 1732; LMA/THCS/15 Tower Hamlets Commissioners of Sewers, minutes, 29 April 1762.

⁵⁰ E.g. Truman brewery: LMA/THCS/13 Tower Hamlets Commissioners of Sewers, minutes, 5 March, 23 April 1741/2, and 2 June 1742.

⁵¹ LMA/SKCS/46 Surrey and Kent Commissioners of Sewers, minutes, 14 July 1757.

⁵² LMA/WCS/57 Westminster Commissioners of Sewers, minutes, 11 Dec. 1772.

⁵³ E.g. LMA/HFCS/18 Holborn and Finsbury Commissioners of Sewers, minutes, 9 July 1772; LMA/CLA/6/AD/29 City of London Commissioners of Sewers, minutes, 19 June 1792.

their wastewater if it was only liquid, and thus living near certain trades often meant being close to offensive smells. This was the matter on James Bannister's mind when he appealed to his sewer commission in 1702 to prevent his neighbour William Pannett connecting to their local sewer in Kensington Square. Pannett was a butcher, and Bannister claimed he wanted to "prevent the smell of such filth for his neighbourhood".⁵⁴ The commissioners ruled that William Pannett had to construct a covered sewer along a different route.

An extensive case study of a sewer being covered as a result of complaints about nuisance can be found in the example of the river Fleet. The Fleet was the once-navigable part of the largest tributary of the Thames in the central London area, the Holbourne River, which arose from springs at Hampstead and Highgate, and passed through Clerkenwell and Farringdon to join the Thames at the location of present-day Blackfriars Bridge. It had once been a major part of London's natural drainage, and at the start of the eighteenth century it was still an open river, as can be seen on the Morgan map in figure 2.6. The Fleet had many competing functions: it drained the areas it passed through, turned the many waterwheels located along its course, as well as provided the opportunity for the illegal disposal of waste for many of the industries on its banks.

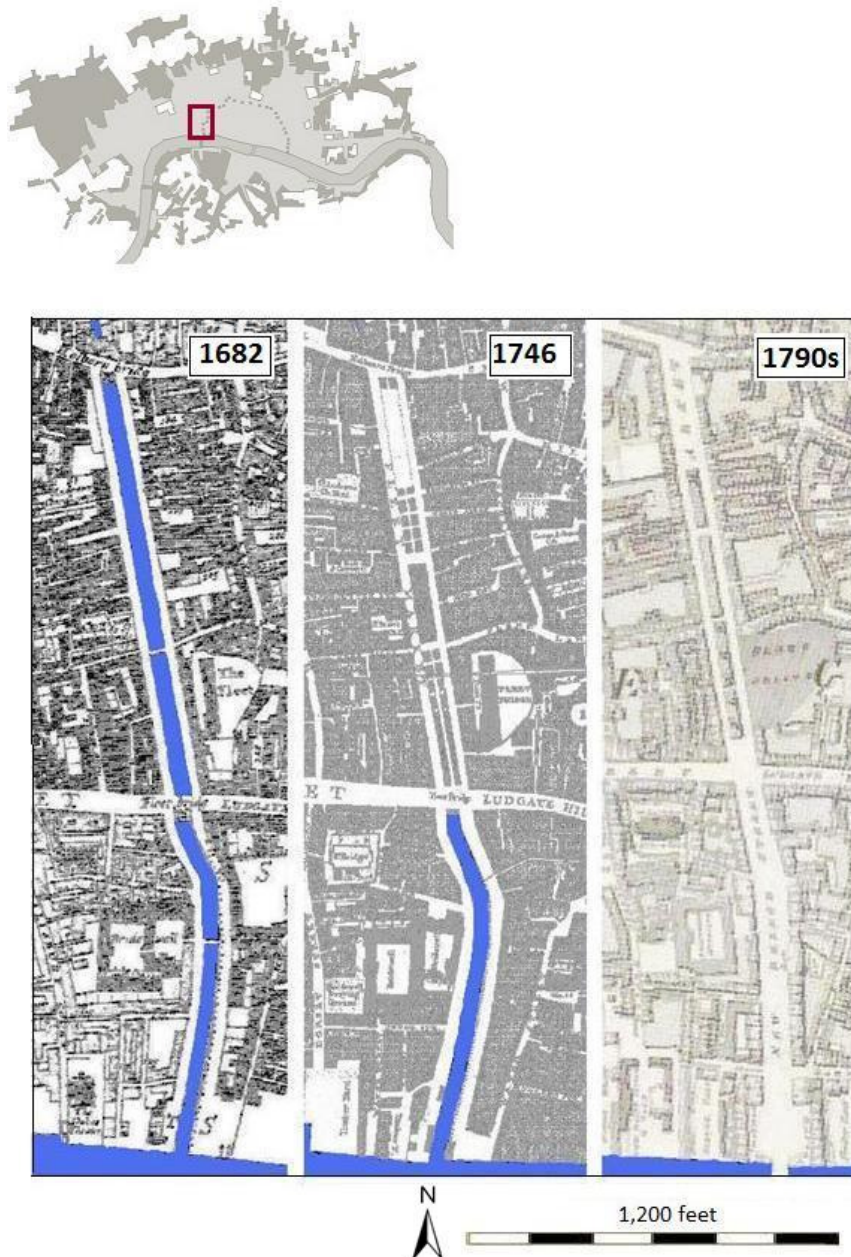
In the minutes of the Holborn and Finsbury Commissioners of Sewers, which administered its course, the Fleet sewer was often mentioned as being full of industrial and domestic waste.⁵⁵ Its foulness was legendary. In 1710 Jonathan Swift composed a poem describing the sort of filth that flowed through it, which included "Sweepings from Butchers Stalls, Dung, Guts, and Blood, Drown'd Puppies, stinking Sprats, all drench'd in Mud, Dead

⁵⁴ LMA/WCS/45 Westminster Commissioners of Sewers, minutes, 7 Sep. 1702 and 2 Nov. 1702.

⁵⁵ E.g. LMA/HFCS/18 Holborn and Finsbury Commissioners of Sewers, minutes, 9 July 1772.

Cats and Turnip-Tops”, many of which originated from the meatmarket at Smithfield.⁵⁶ To minimise its nuisance to surrounding inhabitants the Fleet was covered over in 1733 up to Fleet Bridge, and fully covered over by 1766, turning it into an underground sewer.⁵⁷ Figure 2.11 shows the Fleet in its different stages of this process as depicted on the maps.

Figure 2. 11. The changing Fleet.



From left to right, the Fleet on the Morgan, the Rocque, and the Horwood-Stockdale maps.

⁵⁶ Swift, J., *A description of a city shower* (London, 1710).

⁵⁷ Gray, *A history*, p. 192.

The fate of the river Fleet exemplifies the wider process of covering waterways that changed the city's waterscape during the eighteenth century. As the population increased, the nuisance of offensive open water intensified, resulting in pressure to have it covered over. The covering of open sewers occurred throughout London, and appeared to gather pace as the century progressed. By the end of the 1840s, all sewers in the City of London were covered, as were 82 per cent of those in Tower Hamlets, and 96 per cent of Westminster's sewers.⁵⁸

2.4. Implications.

Urbanisation had profound effects on the relationships between people and water. Growing population density resulted in increased water usage and larger volumes of waste, which flowed into the open watercourses that characterised the early eighteenth-century city. At the same time, the expansion of trades and industries using water, either as a raw material in production or as a means of disposing of waste, further added to the pressures on these water courses. The result was that during the century, complaints about nuisances in relation to open water increased, and sewer commissions came under growing pressure to deal with the mounting problems. The outcome of their efforts was that much of London's previously open water courses were covered over and disappeared below ground.

The physical separation of people from water courses is reflected in the cartographic evidence which, despite the inherent difficulties of interpretation, nevertheless depict the

⁵⁸ Jefferson-Smith, P., 'Before Bazalgette: the Surrey and Kent Commission of Sewers, 1800-1847', *Transactions of the Newcomen Society*, 74 (2004), pp. 131-46, p. 139.

disappearance of surface water in the city over the century. This disappearance effectively distanced people from supplies of water and the means by which drainage was achieved. It was no longer possible for individuals and firms alike to dispose of waste materials in open sewers. Instead they had to connect to the common sewers directly through a network of drains. Nor was it possible for everyone to draw on existing supplies of water, either from the ground via private pumps and wells or from publically available conduits and fountains. Rather, individual households came to rely more on commercial provision of water.

This physical separation therefore had important implications for the ways in which water was provided and by which wastewater was disposed. The greater reliance on water companies and the increased activity of the sewer commissions signified a gradual shift to an increasingly institutionalised way of managing the city's water and drainage. As drainage and water supply became issues that required larger scale interventions, these institutions grew more important. In turn, they shaped the waterscape by constructing entirely new networks of reservoirs, pipes, and sewers that had to be managed and maintained. The next chapter turns its focus on these institutions, and analyses how they operated and responded to the changes in the scale and scope of their operations.

Chapter 3. The institutional framework: water companies and sewer commissions.

The institutional framework that regulated and administered London's water infrastructure during the eighteenth century was complex. The key to understanding this complexity lies in two factors: firstly, London's increasing population and, secondly, the distancing effect that urbanisation had on peoples' relationship with water, as identified in chapter two. Each of these factors implied a larger scale of operation for the managing institutions, both on a physical level, as infrastructure had to expand geographically, as well as on a capacity level, as services had to be supplied to more people.

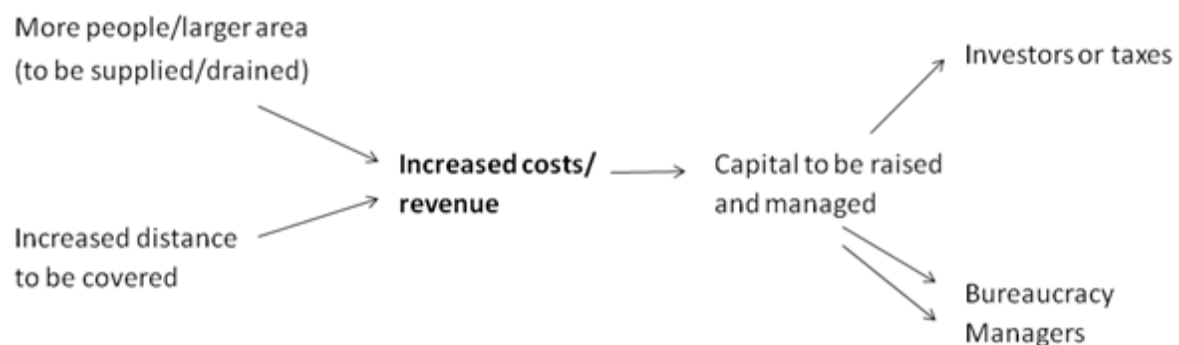
The expansion of large infrastructure systems has several components. The speed and success of it depend, firstly, on the technological ability of the system to either sustain the expansion or incorporate innovations; secondly, on the economic climate and the cost of expansion; and thirdly, on the organisation's own managerial decisions, institutional structures and legislative powers.¹ These last aspects especially were shaped by contingencies from different stages in the institutions' histories.² While all institutions responsible for mediating the distance between water and their users already existed before the start of the eighteenth century, the growing scale of the city made their task considerably more complex. This chapter therefore addresses the backgrounds of the institutions that managed London's water, and examines how they adapted to the increase in scale that their work involved.

¹ Hughes, T.P., *Networks of power: electrification in western society, 1880-1930* (Baltimore, Johns Hopkins University Press, 1993), pp. 2, 462.

² Ibid., p. 404.

The construction and management of a large utility system requires substantial capital. In order to raise this and allocate money to the appropriate part of a growing network, institutions require a larger management, which in turn entails more regulation and administration.³ As depicted in figure 3.1, the expansion of the water infrastructure systems that connected more people and covered larger distances involves an increase in the costs of building and management, as well as a rise in the number of paying customers. The need to collect and manage revenue or taxes necessitated larger managerial efforts and instigated institutional changes, which are discussed in this chapter.

Figure 3. 1. Increasing scale: consequences and adaptations.



While the institutions faced the same issues whether expanding the networks of supply or those of drainage, there was one important difference which was essential to the way they could raise their capital and, as a result, encouraged the managing institutions to follow different trajectories. Unlike the provision of water, drainage and flood prevention were never ‘marketable goods’ to be paid for privately, for the simple reason that it was impossible to exclude people who did not purchase the service — the so-called ‘free-riding’

³ Chandler, A., *The visible hand: the managerial revolution in American business* (Cambridge, Harvard University Press, 1977); also Chandler, A., *Scale and scope: the dynamics of industrial capitalism* (Cambridge, Harvard University Press, 1990), pp. 1-2.

problem.⁴ As water follows gravity and would naturally end up in the sewer system, those who paid for drainage could not prevent others who did not pay for the service from deriving benefit. Free-riders thus had little incentive to pay for improved drainage. However, in contrast to private companies, public authorities had the power to enforce payment rather than leaving individuals to choose and were thus able to spread the cost of constructing and maintaining the drainage network over all those who benefitted. As a result of these underlying dynamics, drainage remained managed by public institutions, while supply, over time, came to be organised by private companies.

This chapter will therefore be comprised of two parts. Firstly it discusses the emergence and subsequent expansion of the supply system, with a focus on the switch from public to private institutions, and secondly, it examines the background and developments of the sewer commissions. As historical contingencies influenced the way in which systems could expand, it is important to gain an understanding of the background of their managing institutions. Each part therefore starts with the emergence of the institutions that managed London's water in the eighteenth century, and then turns to their expansion and organisational change during this period.

3.1. The water companies: historical background.

The history of London's water supply can be broadly divided in four phases. At first, the city depended on traditional sources, to be joined in the Middle Ages by a public supply. From the late sixteenth century onwards, these were complemented by a commercial

⁴ Stiglitz, J.E. and Walsh, C., *Principles of microeconomics* (London, Norton, 2006), p. 255.

supply, which over the course of the next few centuries gradually took over this function. In 1902, a complete overhaul of water supply management took place, in which the remaining companies were bought up and supplanted by one managerial body: the Metropolitan Water Board (MWB). With the exception of this last change, earlier systems of supply did not immediately disappear as new ones emerged, and for much of London's history several types of water supply would have been available.

The traditional sources that Londoners relied on up until the Middle Ages included wells, rain, springs, and water from rivers such as the Thames, Fleet, and Walbrook. There is evidence that in Roman times wells were equipped with water-raising technologies including a chain of buckets, but it is not clear whether this was a private or a public supply.⁵ By the mid-thirteenth century the city's tributaries and groundwater were becoming increasingly polluted, and the City authorities had to look for fresh water sources beyond the limits of London. An infrastructure system was constructed connecting springs at Tyburn to a fountain at Cheapside, where people could freely collect fresh water.⁶ However, the amount of water that this first conduit supplied was insufficient to meet demand, and over the course of the fourteenth and fifteenth centuries extra sources were added to the supply.⁷

Conduit water remained a scarce and contested good, however, and at times conflict arose around issues of wastage and fair amounts of usage, especially as a result of the larger

⁵ Roberts, G., *From Chelsea to Cairo: Taylor-made water through eleven reigns and in six continents* (London, Thomas Telford, 2006), p. 22.

⁶ Lewis, D., "'For the poor to drink and the rich to dress their meat': the first London water conduit", *Transactions of the London and Middlesex Archaeological Society*, 55 (2004), pp. 39-68, pp. 50-1.

⁷ *Ibid.*, p. 54.

water users, such as brewers, cooks, and fishmongers.⁸ While there was no fixed arrangement to finance the maintenance of the conduits, evidence points to several schemes in which these larger consumers were charged for the water they used in their trades, the proceeds of which were to be applied to the costs of maintenance.⁹ However, not everyone was dependent on the conduit: private wells and other water systems were still in operation. Monasteries, palaces, and larger industries often organised their own water supply, either through a network of pipes from a local river or by digging their own deep wells.¹⁰

During the fifteenth and sixteenth centuries it became clear that the conduits could not cope with the additional demands of the growing city, and although the system was expanded several times, water levels were reduced and the supply was slow by the end of the sixteenth century.¹¹ Many of the fountains were destroyed in the Great Fire of 1666, and while most of their infrastructure was rebuilt, the role of the conduits seems to have diminished after this event.¹² A possible contributory factor to their decline was that around 1703 the rights to the springs at Paddington were bought by Richard Soame — who at the same time came into possession of London Bridge Waterworks, and thus had a financial incentive to persuade users to turn to commercially supplied water.¹³ Either way, by 1722 the source of the conduit system at Marylebone was described as having “been for many

⁸ Jenner, M.S.R., 'From conduit community to commercial network? Water in London, 1500-1725', in P. Griffiths and M.S.R. Jenner, eds., *Londinopolis: essays in the cultural and social history of early modern London* (Manchester, Manchester University Press, 2000), pp. 250-72, p. 254.

⁹ Lewis, 'London water conduit', p. 55.

¹⁰ See e.g. Magnusson, R.J., *Water technology in the Middle Ages, monasteries and waterworks after the Roman Empire* (Baltimore, Johns Hopkins University Press, 2001).

¹¹ Tynan, N., 'London's private water supply, 1582-1902', in P. Seidenstat, D. Haarmeyer, and S Hakim, eds., *Reinventing water and wastewater systems: global lessons for improving water management* (New York, Wiley, 2002), pp. 341-60, pp. 343-4; also Magnusson, *Water technology*, p. 140.

¹² Jenner, 'Water in London', p. 260.

¹³ Ward R., *London's New River* (London, Historical Publications, 2003), pp. 115-9.

years intirely useless for the purposes intended (...) and is now in a most ruinous Condition”, while by 1740 the fountains in the City were “quite demolish’d, or intirely out of use”.¹⁴

There was no clean break between the conduit system and the early emergence of the private water companies, and for at least a century they coexisted. Initially, the companies’ function was slightly different from that of the conduits, as they supplied water directly into people’s houses. Before this service, water had to be fetched from a common source, be it a conduit or river, and brought into the house. Much of the population performed this task themselves, although richer inhabitants bought the services of waterbearers to deliver water to their houses.¹⁵ Over time, water had to be transported from ever greater distances, as a result of pollution of central supplies and the expanding city, and fetching water took increasingly more time and resources. The service of bridging this distance by supplying water into people’s houses therefore became an economically viable enterprise.

The first of the companies that provided this service was London Bridge Waterworks, also known as Thames Waterworks. The company, established in 1581, raised Thames water using a waterwheel under the first arch of London Bridge, and its developer, Peter Morris, impressed the City authorities when he demonstrated the power of his supply by projecting a jet over the steeple of the church of St Magnus Martyr.¹⁶ This public display of his ability to supply water enabled him to obtain a 500-year lease for the arch at only ten shillings a year, and also allowed him to gain the custom of several public buildings in the City, which amounted to a £100 annual contract.¹⁷ The company appeared to be successful as in 1584 Morris leased the second arch of the bridge as well, allowing him to expand his supply.

¹⁴ LMA/COL/AC/9/1 City of London, “Cases relating to ye City of London”, p. 47b; *All Alive and Merry or the London Daily Post*, 18 April 1740.

¹⁵ Jenner, ‘Water in London’, p. 259.

¹⁶ Ward, *New River*, p. 17.

¹⁷ Roberts, *Chelsea to Cairo*, p. 33.

Others followed Morris' example of selling water, and in 1594 Broken Wharf Waterworks was established on the riverbank near St Paul, raising Thames water using horsepower. This venture only serviced the immediate locality and remained rather small, supplying about 600 houses in the mid-seventeenth century.¹⁸

The possibility of making money by selling water became obvious, and over the next ten years several proposals were made to establish a company to supply London from springs north of the city. Eventually in 1609 the City Corporation granted powers to Hugh Myddleton to construct a canal from springs at Chadwell and Amwell to London, and this venture became the New River Company.¹⁹ The almost 40 mile long canal was finished in 1613 and the company commenced supplying what were then the northern parts of London. Over the next few centuries, the company expanded its reach to cover all of the City of London and extended towards the West End, eventually becoming the largest water supplier in London. As supply from the springs was inadequate to keep up with the increase in demand, from 1660 onwards the company's water was supplemented by the river Lea.²⁰

These three companies supplied the City of London until the 1666 fire. After this event, the expansion of the capital in combination with the decline of the conduits accelerated the rise of a commercial water supply: between 1666 and the end of the seventeenth century a further six companies were added.²¹ While the earlier companies had mainly supplied the City of London, the new companies were active around the growth areas of Westminster and the West End, as well as in the expanding eastern suburbs. Most of these companies

¹⁸ Jenner, 'Water in London', p. 257.

¹⁹ See e.g. Rudden, B., *The New River: a legal history* (Oxford, Clarendon Press, 1985); Ward, *New River*.

²⁰ Graham-Leigh, J., *London's water wars: the competition for London's water supply in the nineteenth century* (London, Francis Boutle, 2000), pp. 10-11.

²¹ Tynan, 'Private water supply', pp. 346-7.

continued to supply water during the eighteenth century and table 3.1 provides an overview of when they, and later eighteenth-century suppliers, were established.

Table 3. 1. London's private waterworks in the eighteenth century.

	Company	Established	Closed or purchased
The early companies: City of London	London Bridge Waterworks†	1581	1822 (New River Company)
	Broken Wharf Waterworks	1594	1703 (London Bridge Ww)
	New River Company	1613	1902 (MWB)*
The post-fire companies (west of City)	York Buildings Waterworks	1676	1818 (New River Company)
	Hampstead Waterworks	1692	1856 (New River Company)
	Marchant's Waterworks	1695	After 1746 fate not clear
The West End companies	Hyde Park Waterworks	1670?	1731 (Chelsea Ww)
	Millbank Waterworks	1675	1727 (Chelsea Ww)
	Chelsea Waterworks	1723	1902 (MWB)
The eastern companies	Shadwell Waterworks	1668	1808 (East London Ww)§
	West Ham Waterworks	1743	1808 (East London Ww)
The southern companies	Bank End/Thrale	1720	1771 (Borough Ww)
	Borough Waterworks	1771	1820 (Southwark Ww)§
	London Bridge Waterworks†	1761	1822 (Southwark Ww)
	Lambeth Waterworks	1785	1902 (MWB)

† London Bridge Waterworks started supplying south of the Thames in 1761. When the company was dissolved in 1822, its customers and infrastructure north of the Thames were taken over by the New River Company, those south of the river were taken over by the Southwark Waterworks.

* The remaining companies were amalgamated in the Metropolitan Water Board (MWB) in 1902.

§ East London Waterworks and Southwark Waterworks were established in the early nineteenth century. They, in turn, were taken over by the Metropolitan Water Board in 1902.

Based on: Tynan (2002), pp. 346-7, 350-1.

York Buildings Waterworks was established in 1676 and raised Thames water to supply Whitehall and St Martin-in-the-Fields. The company looked to supply the expanding West End as well, and for a while possessed a water reservoir in Marylebone with this intention, but it ventured into financial rough waters after the South Sea Bubble years and for most of

the eighteenth century York Buildings Waterworks was confined to the area around its point of intake near the Strand. Another small concern, Marchant's Waterworks, was established nearby in 1695. It raised water via a waterwheel in the Hartshorne Lane sewer. The Rocque map depicts a water reservoir that is labelled as belonging to Marchant's north of Oxford Street, which suggests that this company was active in Soho around 1746 and probably aimed to supply the West End market as well. The fate of Marchant's company after this date is unknown, but evidently it ceased to exist within a few decades: by the late 1770s the Hartshorne Lane waterwheel was used as a cornmill and no longer raised water.²²

Other companies had their eye on the West End market as well. Hampstead Waterworks was established in 1692 and mainly supplied Hampstead and Highgate from the Hampstead ponds, but by the early eighteenth century also reached parts of St Giles around Tottenham Court Road.²³ Several other small companies supplied more to the west: Hyde Park Waterworks supplied the St James area from springs in Hyde Park, and Millbank Waterworks supplied Westminster from the Thames. Not much is known about either of these concerns; they seem to have been active from the 1670s onwards, and both were taken over soon after the larger Chelsea Waterworks was established in the area.

Chelsea Waterworks was founded in 1723 to supply the suburbs of Westminster and "the new buildings".²⁴ It stored water from the Thames in a series of canals and reservoirs at the present site of Victoria station, retaining the water at low tide with sluices.²⁵ From there the water was pumped to higher reservoirs in Hyde Park and Green Park, from which it supplied most of the West End. The company was established on a larger scale than the earlier ones:

²² *London Gazette*, 15 June 1779.

²³ Hakewill, W.R.H., 'Hampstead Water Works, office and company, 1589-1859' (Unpublished manuscript, 1984, held at LMA/COL/SJ/16/34), p. 305.

²⁴ LMA/ACC/2558/CH/1/47/1 A Proposal for Raising Water from the River Thames, c. 1720.

²⁵ Roberts, *Chelsea to Cairo*, p. 59.

it had a starting capital of £40,000, which enabled it to purchase the infrastructure and take over the customers of the smaller companies that had supplied the area.²⁶ By the 1730s, the West End was thus mainly supplied by Chelsea Waterworks and the New River Company, with smaller parts supplied by the Hampstead and York Buildings Waterworks.

East London was initially supplied by Shadwell Waterworks, which was set up by Thomas Neale in 1668 and supplied Shadwell, Stepney, and Wapping with Thames water. As London expanded eastwards during the eighteenth century West Ham Waterworks was established in 1743 to supply Mile End, Stepney, and Stratford from the river Lea. These companies initially competed against each other, but reached an agreement in 1785 not to undercut each other on price.²⁷ By 1800, however, the construction of the London Docks in Wapping posed significant problems to the two companies, both because the mains would have to be cut as a result of construction, and because many customers' houses were demolished to make way for the new docks. As an outcome, the remaining water supply network was bought in 1808 by the East London Waterworks — a newly established company.²⁸

South of the river, the commercial supply of water had a slower start as a result of a smaller population and the greater abundance of surface water. The first company to start supplying Southwark was located on the banks of the Thames, and indicated on maps as Bank End. It was later known as Borough Waterworks, although it is also possible that this was a new company that took over Bank End.²⁹ It is likely that this company grew out of the

²⁶ Graham-Leigh, *London's water wars*, p. 11.

²⁷ LMA/ACC/2558/EL/A/2/B28/1 Agreement between West Ham Waterworks and Shadwell Waterworks, 1785.

²⁸ Graham-Leigh, *London's water wars*, pp. 13, 34.

²⁹ In the *Gazetteer and New Daily Advertiser* of 24 July 1767 Borough Waterworks was reported as having recently acquired an engine, which would allow them to supply the neighbourhood. On 4 July 1767 in the same paper it had been reported that Bank End Waterworks was laying new pipes and a reservoir. This was possibly the same company.

private supply of the Thrale brewery, as these enterprises are often linked.³⁰ London Bridge Waterworks also supplied this area from 1761 onwards, first via pipes over London Bridge, but eventually the company leased the southern-most arch of the bridge for this supply. The first large company to be established in the south was Lambeth Waterworks, which drew water from the Thames near the site of Waterloo Bridge.³¹ This company was only set up in 1785, after the population south of the Thames had begun to expand rapidly following the completion of Westminster and Blackfriars Bridges.

3.2. The water companies: enlarging scale and raising capital.

While the total number of companies was the same in 1800 as it had been in 1700, new companies formed and old ones disappeared, and a larger area was supplied with water. Figures 3.2 and 3.3 show the approximate areas covered by the companies at the start and end of the eighteenth century, layered over the expansion of London. From these figures the physical growth of the companies is clear: they had to keep up with supplying a growing number of customers as well as having to develop ways of dealing with the increasing distance that needed to be covered. New companies, such as West Ham and Lambeth Waterworks, were established in expanding areas where no company was active, while other companies increased in scale.

³⁰ See e.g. Humpherus, H., *History of the origin and progress of the Company of Watermen and Lightermen of the river Thames with numerous historical notes, Volume II* (Wakefield, E.P. Microfilm, 1981), p. 272.

³¹ LMA/ACC/2558/LA/1/1 Lambeth Waterworks, minutes, 25 April 1785.

Figure 3. 2. The water companies in 1700.

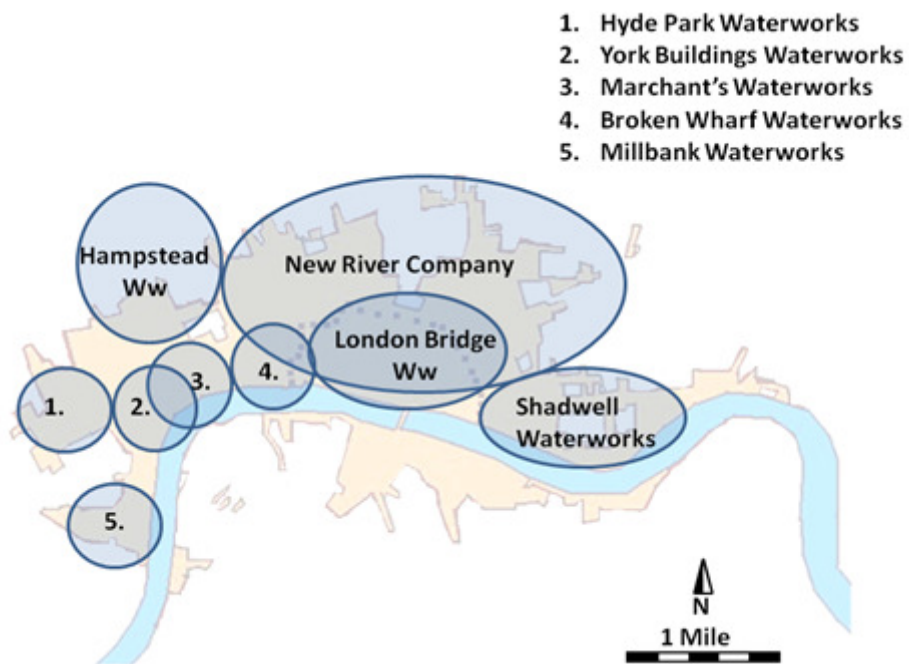
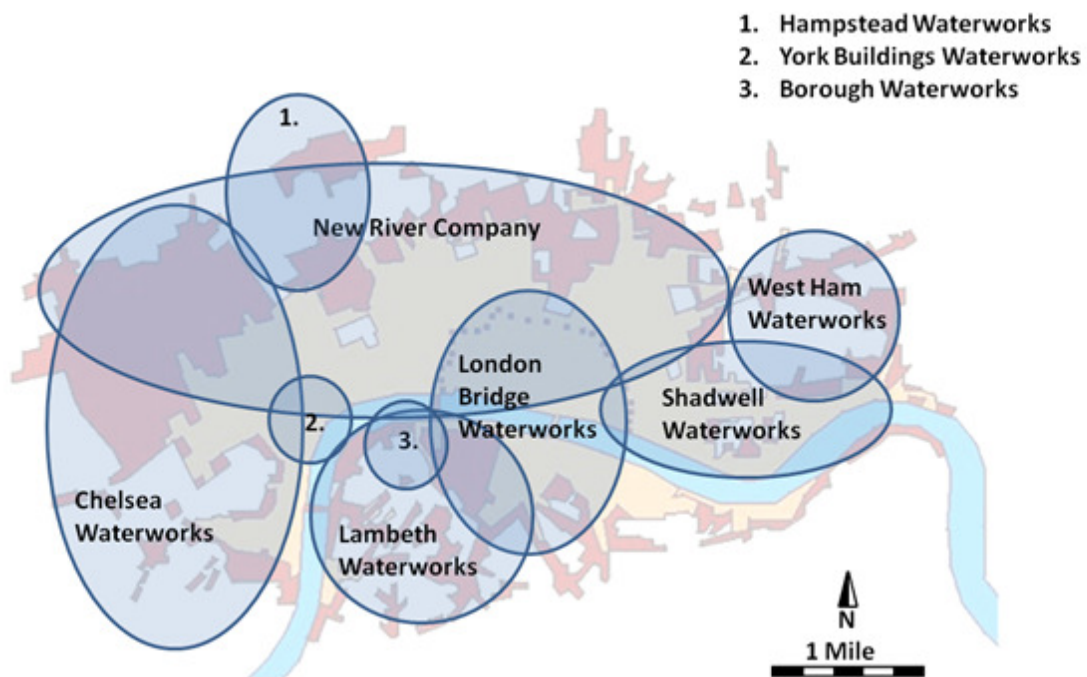


Figure 3. 3. The water companies in 1800.



New companies required major capital investment in order to construct the initial infrastructure before they could make any profit, but the increase of scale also put pressure on the longer-established companies, both in terms of expanding their own networks as well as making sure they could manage their organisation efficiently.

In order to mobilise the large amount of capital needed to lay out their pipes and engines, commercial undertakings in early modern London had two options: partnerships or joint-stock companies. The main difference was the perpetual succession in joint-stock companies, whereas a partnership had to be sold or bequeathed at the demise of one of the partners.³² However, raising money was not the only hurdle: any new company required legislation, such as Letters Patent or a Private Act from Parliament, specifying the location, way of acquiring water, area of distribution, and the capital that could be raised.³³ Some potential companies never materialised because of opposition in Parliament. For example, attempts to establish a company bringing water from the river Colne to London stalled on objections from, amongst others, millers that used the intended water source.³⁴ Other plans failed as a result of opposition from existing companies. For a company to be successful, therefore, there was often the need for powerful alliances with the Crown, the City Corporation, or other vested interests.³⁵

The City Corporation had an interest in helping the early water companies. London Bridge Waterworks had been given the lease of a London Bridge arch for the relatively low price of ten shillings a year. In addition, this enterprise was supported by an alderman, who lent

³² The other option was a regulated company, which also established a monopoly for the company. This was often the case for trading companies, such as the East India Company. Carruthers, B., *City of capital: politics and markets in the English Financial Revolution* (New Jersey, Princeton University Press, 1996), p. 131.

³³ Tynan, 'Private water supply', p. 349.

³⁴ Journals of the House of Commons, XIX, p. 580.

³⁵ Jenner, 'Water in London', p. 258.

money to its founder, Peter Morris.³⁶ Broken Wharf Waterworks' entrepreneur Bevis Bulmer was also loaned £3,000 by the City Corporation towards the cost of setting up his company, and a few years later, when this company was taken over by Thomas Paradine, he was again provided with a loan.³⁷ By supporting the early water companies the City authorities ensured a water supply without needing to find a solution for the ailing condition of the public conduits. Indeed, in Paradine's lease, he promised to supply a quarter of the water he raised to the conduits, as well as making the water freely available to the City in case of fire, or other calamity.³⁸ The provision of free water in case of fire had also been an aspect of Morris' first lease.³⁹ The City thus gained a cheap solution for its water problems while all the risk and investment remained with the entrepreneurs.

Peter Morris seems to have financed the London Bridge Waterworks mostly by himself, with the help of the aforementioned loans. By 1701 the company was still in the hands of his descendents, who sold it for £43,000 to Richard Soame, a man described as either a goldsmith or a merchant. Soame did not raise all this money by himself. In fact, £30,000 of it was raised by three other City goldsmiths.⁴⁰ Around the same time, London Bridge took over Broken Wharf Waterworks, and Soame's family members purchased the rights to the sources of the Marylebone conduit springs, although these were never exploited.⁴¹ It seems that they wanted to prevent the possibility of another water company gaining control over these springs, and so tried to eliminate competition and keep all custom for themselves.⁴² As a result, Soame and his family were able to incorporate the company with a nominal

³⁶ Jenner, 'Water in London', p. 258.

³⁷ Roberts, *Chelsea to Cairo*, p. 66.

³⁸ Ward, *New River*, p. 18. This is discussed further in chapter 7.

³⁹ LMA/ACC 2558/MW/C/15/222/2 London Bridge Waterworks' lease for first arch of London Bridge, 1581.

⁴⁰ Ward, *New River*, p. 111.

⁴¹ *Ibid.*, p. 115.

⁴² *Ibid.*, p. 119.

capital of £150,000, which he initially tried to raise by dividing it in three hundred £500 shares.⁴³ These shares seem to have been too expensive, as by 1708 the company's shares were sold as 1,500 £100 shares.⁴⁴ By 1741, the company had 81 shareholders.⁴⁵

More is known about the investment needed to set up the New River Company. Hugh Myddleton, who was a City goldsmith as well, had initially intended to finance the project through a private partnership, but before the project was completed he had to apply to King James I for money. This was either because he was in genuine need of it or, as has been suggested, to get the interest of the Crown on board — firstly, to ward off competition from London Bridge Waterworks, and secondly, to force large landowners along the intended canal's course to cooperate.⁴⁶ The King agreed to fund half of the expenditure in return for half of the company's profits, but the Crown sold its share back to Myddleton in 1633 in return for an annual rate of £500.⁴⁷ Meanwhile, Myddleton's half had been sold in 36 shares, which cost £100 each, but during the construction of the New River canal a further £189 was called up, and thus each shareholder initially contributed £289 to the company.⁴⁸

Nine of the 36 shares were held by Hugh Myddleton or members of his family, which indicates that he must have had some capital himself. Other shareholders included the owner of the site of the New River Head, the company's main reservoir in Islington, and several other members of City livery companies, who would have been wealthy London investors.⁴⁹ The shares started making a small annual dividend from the 1630s onwards, but

⁴³ Matthews, W., *Hydraulia* (London, Simpkin, Marshall, and Co, 1835), p. 35.

⁴⁴ Graham-Leigh, *London's water wars*, p. 10.

⁴⁵ LMA/ACC/2558/MW/C/15/12 List of proprietors of London Bridge Waterworks.

⁴⁶ Tynan, 'Private water supply', p. 345. The City Corporation was not interested in helping him as they already had the supply from London Bridge and Broken Wharf Waterworks. *Minutes of evidence taken before the select committee on the supply of water to the metropolis*, PP 1821 (706), p. 71.

⁴⁷ This reflected the dividends of the King's shares at this time. Rudden, *New River*, p. 35.

⁴⁸ Rudden, *New River*, p. 19.

⁴⁹ *Ibid.*, p. 27.

real wealth arising from capital growth was only gained over time. In 1695 it was said to be the company with the third-largest capital in the country, after the East India Company and the Bank of England.⁵⁰ By 1712, a century after its establishment, annual dividends were over £200 and a share was traded for £7,000.⁵¹

Goldsmiths were involved in both the London Bridge Waterworks as well as the New River Company. While there is evidence to suggest that Myddleton initially trained as an actual goldsmith, seventeenth-century goldsmiths were often not active as such, but rather operated as investors. As members of London's Goldsmiths' Livery Company they could practise any trade they wanted, and many members had wider trading interests and were heavily involved in the emerging banking system.⁵² As part of the Financial Revolution taking place during the seventeenth and eighteenth centuries, the accumulation of wealth generated by trade, industry, and agriculture provided a pool available for capital investments, and wealthy merchants were more willing to re-invest in new financial ventures than in land.⁵³ Supported by the shift in the institutional framework, as identified in chapter one, an impersonal capital market developed, in which the financial property rights of creditors were enforced by a legal system that generated sufficient trust for people to part with their money. The accumulated wealth was coaxed into a circle of credit, which became the key to economic growth.⁵⁴ A group, or class, of moneyed men emerged, the majority of whom were merchants and financiers, who were mostly based in London and invested in government securities, companies, and large-scale ventures.⁵⁵

⁵⁰ Rudden, *New River*, p. 98.

⁵¹ *Ibid.*, p. 63.

⁵² Roseveare, H., *The Financial Revolution, 1660-1760* (London, Longman, 1991), p. 12.

⁵³ Carruthers, *City of capital*, p. 116.

⁵⁴ Roseveare, *Financial Revolution*, p. 4.

⁵⁵ Glaisyer, N., *The culture of commerce in England, 1660-1720* (London, Royal Historical Society, 2006), p. 3.

By the end of seventeenth century the joint-stock company was a common way to move capital. Only a small number of shareholders held decision-making power (the governor, deputy, and directors), while most of the rest were mainly there as passive investors whose sole interest was to make money.⁵⁶ The water companies attracted such investors, who saw them as potential sources of large incomes, possibly spurred on by the dividends generated by the New River shares. However, this could also play against the success of a company. York Buildings Waterworks' investors seemed to have been mainly interested in the waterworks because of the several side-ventures that were attached to this company. In 1719 the company was sold for £7,000 to Case Billingsley, who exploited the fact that its charter included the right of landownership, which he used to buy cheap property in Scotland after the 1715 Jacobite Rising. The new shareholders all seem to have been investors trying to make money, and were also involved in several other ventures, including the Royal Exchange Assurance Company.⁵⁷ As the company's capital was heavily tied up in these other ventures it ended up losing a lot of money during the Southsea Bubble crisis, and as a result had to leave the West End market.

The London water supply companies all took a while to become profitable. As a result of the large investment needed to start up or to expand into a new area, it often took years before a dividend could be returned to the shareholders. The companies that were set up during the eighteenth century — Chelsea Waterworks, West Ham Waterworks, and Lambeth Waterworks — had different strategies to raise finance. Chelsea Waterworks was set up as a joint-stock company, and was able to raise £40,000 in 2,000 shares of £20 each. Most of these shares were held in batches of five or ten, making them investments of £100

⁵⁶ Carruthers, *City of capital*, p. 134.

⁵⁷ Cummings, A.J.G., 'The York Buildings Company, a case study in eighteenth century corporation management' (PhD thesis, University of Strathclyde, 1980), pp. 29, 34, 310.

to £200, on a level with the shares in other waterworks.⁵⁸ This was found to be insufficient, however, and in 1733 a further £30,000 was authorised to be raised, although the company struggled to attract shareholders this time as there had not been any dividends by that date. In fact, it was not until the 1750s that the company made any regular profits.⁵⁹

West Ham and Lambeth Waterworks were set up on a smaller scale. West Ham was established as a partnership of Resta Patching, who had “contrived the scheme”, and Thomas Byrd, who was to finance it.⁶⁰ Patching was given a salary of £50 as he would be doing all the practical work, and he would receive one-third of the profits. Byrd seems to have been the sole financier. More is known about the early financing of Lambeth Waterworks. The idea for a water company was conceived by a group of seven men who thought that supplying Lambeth from the Thames would not come at too great a cost as the elevation of the ground was lower than in the north. At their first meeting, they had estimated the number of households that were likely to take water, as well as the infrastructure required, including the pipes, an engine, and ground purchases.⁶¹ The initial expenses were estimated as costing £3,100, with annual outgoings of £380.⁶² They issued 32 shares of £100 each in order to raise the initial investment, which were mostly divided amongst the men themselves.

All companies had to employ a number of people to carry out the day-to-day tasks of running the system. The positions that needed to be filled from the beginning included an engineer, in charge of setting up or improving the physical infrastructure of the company, a

⁵⁸ Roberts, *Chelsea to Cairo*, p. 56.

⁵⁹ Ibid.

⁶⁰ SEAX/D/DU/621/1 West Ham Waterworks, articles of agreement, 1745.

⁶¹ LMA/ACC/2558/LA/1/1 Lambeth Waterworks, minutes, 25 April 1785.

⁶² Ibid. The annual outgoing included salaries for their employees, coals for the engine, repairs, and £100 for any contingencies. Their estimated annual income would come to £750, so they were expecting annual profits of £370.

surveyor, who surveyed and mapped out the company's works, and kept an eye on the infrastructure, and a clerk, who acted as the go-between linking the staff and the directors, and attended meetings.⁶³ The engineer was often a professional who also did other work, and was hired by the companies on a consulting basis.⁶⁴ For example, London Bridge Waterworks employed noted engineers such as George Sorocold and John Smeaton. Once the technology was installed, the surveyor often became responsible for keeping an eye on it, and millwrights or engine workers had to be hired on a permanent basis in order to run the engines.⁶⁵ As they expanded their systems, the companies also employed pipe-borers and bricklayers, usually on a contract basis.

The companies' employees that the customers encountered as part of their contract were the collectors and the turncocks. The turncock was in charge of turning services on and off by directing water from the mains into service pipes according to their schedule. In case of fire, they were responsible for directing the water towards the area where it was needed. As a company expanded, more turncocks were required. The New River Company employed 8 of them in 1700, but by 1756 their number had increased to 16.⁶⁶

The collectors dealt directly with the customers. They were mainly responsible for collecting the water-rent quarterly or twice a year in a pre-arranged tavern or public house, but also signed up new customers. The New River Company's collectors were ordered to keep track of the water-users in their district. Especially in the case of stable yards, they had to keep an eye out on the number of houses, coach houses, or tap houses that used water,

⁶³ Ward, *New River*, p. 79.

⁶⁴ *Ibid.*, p. 80.

⁶⁵ Lambeth Waterworks estimated that its engineer, Thomas Simpson, attended on average twice a week. LMA/ACC/2558/LA/1/2 Lambeth Waterworks, minutes, 17 Oct. 1797.

⁶⁶ Ward, *New River*, p. 83.

as these were often rated higher.⁶⁷ The collectors were a go-between linking the managers of the company and their customers, and often relayed complaints about supply. The remuneration of the New River Company's collectors was that they could keep a shilling for each pound they collected, equivalent to a five per cent commission. Presumably, this commission would have encouraged them to chase up all the rents.⁶⁸ As they handled large amounts of money they were required to submit a £1,000 security against the possibility of defalcation.⁶⁹

As a company increased in size, more collectors were needed as well. A 1797 report for Lambeth Waterworks' directors stated that up until that point they had used only one collector, but as the company had grown so much an additional one would be required.⁷⁰ The New River Company had had eight collectors in 1684, a number that grew to 14 by 1756.⁷¹ In 1769, when the company had 26,197 tenants, it still employed 14 collectors, which gave each collector's district an average of 1,871 tenants.⁷² By 1804 the company had grown to 38,264 tenants in London, and its area had been divided into 15 districts, but each of those now averaged 2,551 tenants.⁷³ This indicated an increase in work and income for the collectors: while in 1769 a district provided on average almost £2,700 per year, which would give the collectors a yearly salary of £134, by 1804 the collection per district had risen to over £4,200 on average, providing a collector with £212 a year.⁷⁴ In addition, as the increase in customers was unequally distributed over the company's territory, there was a

⁶⁷ LMA/ACC/2558/NR/1/1 New River Company, notes on collectors, c. 1769.

⁶⁸ Ward, *New River*, p. 82.

⁶⁹ LMA/ACC/2558/NR/1/1 New River Company, notes on collectors.

⁷⁰ LMA/ACC/2558/LA/1/2 Lambeth Waterworks, minutes, 17 Oct. 1797.

⁷¹ Ward, *New River*, p. 81.

⁷² LMA/ACC/2558/NR/12/1 New River Company, rent book, 1769.

⁷³ *Select committee*, PP 1821 (706), p. 207. This excludes the 149 tenants the New River had alongside its course, who had their own collector.

⁷⁴ It is possible that the districts were split up in smaller portions. The company's 1804 ledger shows payments to collectors of between £70 and £190. LMA/ACC/2558/NR/9/29 New River Company, ledger, 1804.

re-organisation of its collection districts which kept certain collections from growing too large, and a new collection was added to help with the growth of customers in the West End. Even so, the districts of Marylebone, Bloomsbury, as well as Islington, had grown to contain over 3,000 tenants.⁷⁵

Enlarging a company's infrastructure was less capital intensive than establishing a new one, and so the larger companies spent much of the eighteenth century expanding their business. By doing this, they raised more money, and once the initial costs of expansion were paid off they could start sharing profits with their investors. This took time, and investment in water infrastructure should therefore be thought of as long-term investments. Chapter five will discuss the expansion of the water supply networks in more detail. For now, this chapter moves on to examine the trajectory of London's drainage authorities, which fit into a wider history of local government.

3.3. The commissioners of sewers: historical background.

The management of eighteenth-century London's drainage system encountered similar issues relating to an enlarged scale of operation. The increased area that drainage structures had to cover as a result of urban expansion resulted in the multiplication of the amount of work and repairs required. In order to manage this increased workload, London's drainage authorities underwent a number of institutional changes that were typical of the wider changes in urban administration that took place over the eighteenth century. The

⁷⁵ *Select committee*, PP 1821 (706), p. 207.

administrative framework by which London was governed at this time was little short of chaotic. There was no single municipal authority and while the City Corporation had jurisdiction within the City itself, the rest of the metropolitan area was governed by a mix of parish vestries, Justices of the Peace (JPs), and ad hoc committees. By 1800 there were at least 300 different bodies responsible for aspects of London's governance.⁷⁶

At a county level, there were the JPs, who were appointed by the Crown and whose traditional duties involved maintaining the peace and holding petty sessions, but who were also responsible for certain countywide issues such as bridges and highways. Over time, new duties were added to their role, and for much of the eighteenth century JPs also exercised important functions associated with the regulation of wages and apprenticeships, as well as the operation of the poor laws. At the city level, the borough was an urban area which had received a charter with certain privileges from the Crown, and was able to establish its own administration, had ownership of its own corporate property, and which could also have its own bench of JPs.⁷⁷ These kind of municipal corporations, which included the City of London, were exempted from the county's government and had their own elected bodies which were, to greater or lesser extent, democratic.⁷⁸

Outside the City of London, the basic unit of local governance was the parish, which was essentially an ecclesiastical unit responsible for local law and order, provision for the poor, and providing common amenities. As an entity of government the parish also had important responsibilities relating to the regulation of the built environment, including the removal of nuisances, lighting, cleansing, and the supply of water through the parish pump. Eighteenth-century parishes ranged widely in size, population, and the ways in which officials could be

⁷⁶ Byrne, T., *Local government in Britain* (London, Penguin Books, 2000), p. 14.

⁷⁷ *Ibid.*, pp. 14-5.

⁷⁸ Smellie, K.B., *A history of local government* (London, George Allen, 1968), p. 18.

appointed. How a vestry was selected, for example, could vary considerably even between neighbouring parishes.⁷⁹ During the eighteenth century parish government came under increasing strain as a result of social and economic changes. Rapid urban growth and changing social geographies undermined the system of obligation that parish governance was based on, a system in which ratepayers were required to perform a range of civic duties, such as sitting on juries or taking up local government offices without remuneration.⁸⁰ As long as the parish remained a knowable community within which a sense of personal obligation existed, these kinds of voluntary arrangements sufficed. The newly urbanising areas, in contrast, had no long-established economic and social relations that formed the basis of parish government, and the inhabitants of these places were often unknown to each other.⁸¹ Under these circumstances, ratepayers became increasingly reluctant to serve a parish office. As a result, parish offices began to be filled by professional staff paid a salary rather than local ratepayers performing those duties as part of their civic obligation to the community.⁸²

As the duties heaped on local government expanded, additional institutions were established. These bodies usually dealt with one specific issue, such as turnpikes, paving, or drainage, and would often administer an area comprised of several parishes. More significantly, most of these ad hoc bodies were authorised to raise taxes separately from national and local rates, in order to fund their specific activities. Sidney and Beatrice Webb called this type of institution 'statutory authorities for special purposes', and showed how

⁷⁹ Some parishes had vestries, which were local committees that exercised a certain degree of supervision on officers executing the above-mentioned tasks. Vestries could be either open or select. Smellie, *History of local government*, p. 13.

⁸⁰ Webb, B. and Webb, S., *English local government from the Revolution to the Municipal Corporations Act, volume 4: statutory authorities for special purposes* (London, Longmans, Green and Co, 1922), pp. 358-9.

⁸¹ *Ibid.*, pp. 361-3.

⁸² The 1601 Poor Law Act was the first to empower justices to appoint overseers to administer poor relief. Bell, W.G., 'The birth of the London rate-payer', *History*, 12 (1927), pp. 117-129, pp. 125-6.

their number and activities greatly increased after 1700.⁸³ When the local government system was reorganised in 1835, all such institutions together raised almost £3 million a year, which was close to half of the total of all monies raised by local government authorities.⁸⁴

Within these institutions, even more so than in parish or borough administration, developments in the manner of local governance occurred. Over time, duties that were previously performed without remuneration under the obligatory system, such as cleaning the streets and fixing the sewers, were contracted out to professional staff and paid for by taxes.⁸⁵ The statutory authorities for special purposes developed a system of “administration by committees of representatives of the electorate of ratepayers, directing and controlling a staff of professional officers”, to deal with the problems that the parish system could not cope with.⁸⁶

The sewer commissions formed part of this system of statutory authorities. The defence of land from encroachment by the sea, which was the sewer commissions’ original purpose, had a history of being organised on an ad hoc basis, separately from the parish or county government. Since the failure of existing flood protection structures would endanger the general safety of the public, protecting them fell under the special prerogative of the Crown and trumped other property rights in these structures.⁸⁷ Under these powers, special appointed justices had been sporadically in charge of this issue since at least the thirteenth century. However, they often lacked authority to force people to comply with their

⁸³ Webb and Webb, *English local government*, p. 7.

⁸⁴ National figure. *Ibid.*, p. 2.

⁸⁵ *Ibid.*, p. 430.

⁸⁶ *Ibid.*, pp. 9-10.

⁸⁷ Kennedy, G.G. and Sandars, J.J., *The law of land drainage and sewers* (London, Waterlow Bros and Layton, 1884), pp. 32-3.

measures. In order to solve this problem, the 1531 Bill of Sewers empowered the state to appoint sewer commissions wherever they were required, which in turn were authorised to make their own byelaws and raise money by taxing everyone who benefitted from repairs.⁸⁸ These commissions were originally mandated for several years, but over time, as their duties increased, they evolved into permanent institutions.

Initially, these duties had mainly been the protection from flooding by sea, river or streams, but because each sewer commission was established under a local act they would often have slightly different powers, depending on their area of jurisdiction. Some of them had specific functions, such as the one for Glamorgan, whose orders included the prevention of deposits of sand from the sea.⁸⁹ For the various sewer commissions that were set up to drain the fens in eastern England in the first half of the seventeenth century, the removal of surface water became an important secondary function.⁹⁰ Around London, too, the need for drainage as well as protection from the Thames prompted the creation of various commissions. The first one was the commission for Surrey and Kent in 1554 which was, significantly, the area that suffered most from flooding.⁹¹ London's need for drainage was reflected in a separate Sewer Act of 1605, which authorised the several sewer commissions in the metropolitan area with powers over all "Walls, Ditches, Banks, Gutters, Sewers, Gotes⁹², Causeys, Bridges, Streams and Watercourses, navigable or not, within the Limits of Two Miles, of and from the City of London, which Waters have their Course and

⁸⁸ 23 Hen VIII c. 5, *The bill of sewers*, 1531; Webb and Webb, *English local government*, p. 17.

⁸⁹ Hargrave, F., *The laws of sewers* (London, 1732), p. 19.

⁹⁰ Darby, H.C., *The draining of the fens* (Cambridge, Cambridge University Press, 1940).

⁹¹ LMA/SKCS.

⁹² A gote or goat is a machine that raises water. Hargrave, *Laws of sewers*, p. 25.

Fall into the River of Thames".⁹³ Under this Act the London sewer commissions were given jurisdiction over water courses and structures at a distance from the Thames banks, and they were evidently set up to facilitate the area's drainage.⁹⁴ The river itself, however, fell outside the sewer commissions' jurisdiction, and was managed by a separate administration.⁹⁵

By the eighteenth century, the administration of the sewers in London was organised by eight commissions (see figure 3.4). Seven were appointed by the Crown: those of Westminster, Surrey and Kent, Holborn and Finsbury, Poplar, St Katharine, Tower Hamlets, and Greenwich (not shown on this map).⁹⁶ The City Corporation appointed the City Commissioners of Sewers. The commissions' areas were based on historical administrations rather than on natural drainage areas, although the boundaries between jurisdictions were not always clear.⁹⁷ As a result of this problems could arise, particularly when properties drained through more than one jurisdiction.⁹⁸ There were particular difficulties for

⁹³ 3 Jac I c. 14, *Statute of sewers*, 1605; Darlington, I., 'The London commissioners of sewers and their records', in F. Ranger, ed., *Prisca Munimenta: studies in archival & administrative history* (London, University of London Press, 1973), pp. 282-98, p. 283.

⁹⁴ There was some controversy over the phrase "Limits of Two Miles" as both the Westminster and Middlesex as well as the Surrey and Kent Commissioners acted under Letters Patent that allowed them to operate at a farther distance. See e.g. Hanley, J.G., 'The Metropolitan Commissioners of Sewers and the law, 1812-1847', *Urban History*, 33 (2006), pp. 350-68.

⁹⁵ The conservancy of the Thames from Yantlet Creek (at the mouth of the Thames) to Staines (where the tides reached) had been entrusted to the Corporation of the City of London since 1197. Their jurisdiction covered all streams and creeks with tidal water, and thus included part of the rivers Medway and Lea.

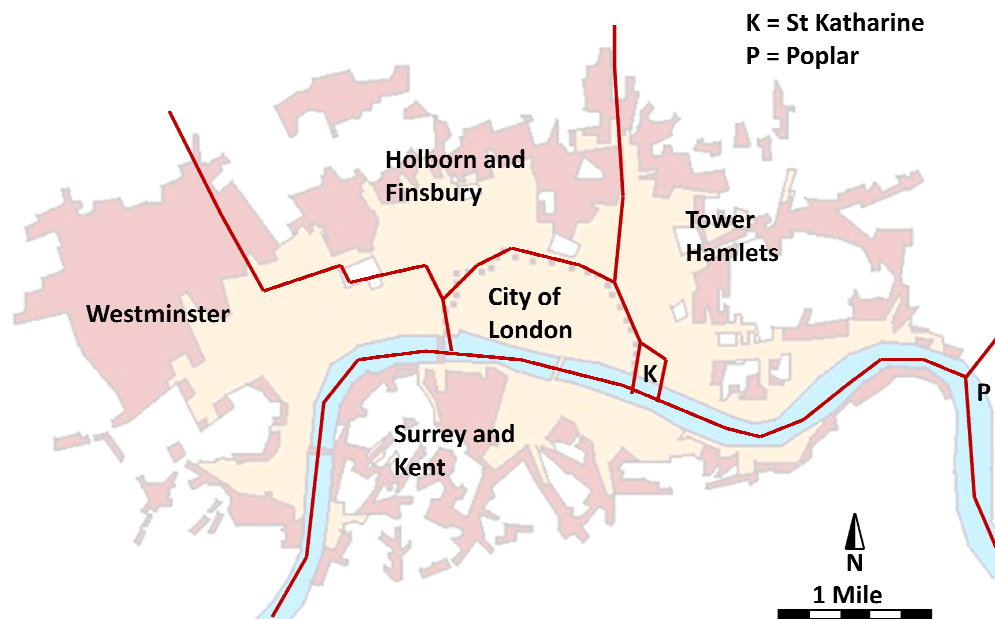
⁹⁶ This thesis mainly deals with the Westminster, Surrey and Kent, Holborn and Finsbury, and Tower Hamlets commissions. The Poplar commission's records were not available as a result of their poor state, and Greenwich has been omitted as a result of its distance from the city.

⁹⁷ The areas were probably based on pre-1531 systems of drainage control. Webb and Webb mention the peculiarity that the Surrey and Kent commission comprised two countries, but did not probe into the reasons underlying this fact. In 1732 the Holborn and Finsbury and City Commissioners had an altercation about their demarcation line in the Sharps Alley sewer. In the same year, the Holborn and Finsbury Commissioners of Sewers had a similar conflict with the Tower Hamlets Commissioners of Sewers about their boundary. LMA/HFCS/16 Holborn and Finsbury Commissioners of Sewers, minutes, 21 Jan. 1731/2; LMA/HFCS/16 Holborn and Finsbury Commissioners of Sewers, minutes, 14 July 1732; LMA/THCS/11 Tower Hamlets Commissioners of Sewers, minutes, 17 March 1731/2; LMA/HFCS/16 Holborn and Finsbury Commissioners of Sewers, minutes, 28 April 1732.

⁹⁸ See e.g. LMA/HFCS/16 Holborn and Finsbury Commissioners of Sewers, minutes, 20 Oct. 1732.

commissions that had no direct access to the Thames. The Holborn and Finsbury commission, for example, was in this situation and therefore had to channel its drainage through the City commission's sewers.⁹⁹

Figure 3. 4. The London sewer commissions.



Based on: Jefferson-Smith (2004), p. 132.

The areas that the several London sewer commissions administered were diverse, ranging from the most built-up parts of the city to long stretches of marshland. In some places they had to administer sluices and embankments in uninhabited lowlands, in others they had to deal with wastewater in densely populated urban districts.¹⁰⁰ The southern commissions had to deal with flooding, as some of their land was below the high tide water mark, which meant that they could only discharge their sewage into the river for a few

⁹⁹ Unfortunately the commissions did not work together effectively by e.g. synchronizing their cleaning. This caused problems for people of St Luke's parish, see LMA/CLA/6/AD/3/12 City Commissioners of Sewers, minutes, 29 Jan. 1741/2.

¹⁰⁰ Webb and Webb, *English local government*, p. 58.

hours a day — a problem that was not solved until Joseph Bazalgette's intercepting sewage network was constructed in the mid-nineteenth century.¹⁰¹ They also had to deal with a variety of natural events ranging from sea storms to exceptionally high tides that periodically swept up the Thames. This diversity in topography, population, and impact of natural events, coupled with variations in the legal framework within which each individual commission operated, resulted in diverse forms of administration and differences in the kind of responses.¹⁰²

3.4. The commissioners of sewers: administration and enlarging scale.

The earliest sewer commissions had been constructed as judicial bodies. Commissioners met at a Court of Sewers in which cases of nuisances, disrepair, or other sewer related issues were presented and decided on by a jury.¹⁰³ The actual commissioners, of which at least six were required to be present in court, were endorsed with the same powers as the JPs, namely to tax, charge, and punish people, and had the executive power to carry out the jury's decisions.¹⁰⁴ This jury, members of which were the same people as those who qualified as grand jury men at the county's Quarter Sessions, did all the practical work: they inspected sewers, sluices, and river walls in the commission's district, made 'presentments' about what needed repairing or cleaning up, and decided who would be held responsible for

¹⁰¹ Sunderland, D., "'A monument to defective administration'? The London Commissioners of Sewers in the early nineteenth century', *Urban History*, 26 (1999), pp. 349-72, p. 361.

¹⁰² Webb and Webb, *English local government*, p. 58.

¹⁰³ *Ibid.*, p. 22.

¹⁰⁴ C.M., *The law of sewers* (London, 1762), p. 7; Darlington, 'London commissioners of sewers', p. 282; Jefferson-Smith, P., 'Before Bazalgette: the Surrey and Kent Commission of Sewers, 1800-1847', *Transactions of the Newcomen Society*, 74 (2004), pp. 131-46, p. 131.

the works to be done.¹⁰⁵ The presentments could be either 'private' or 'public'. Private presentments occurred when the obligation of repair was to be laid on the owners, and these owners were presented with a date by which the issue should be dealt with, or faced the prospect of paying a fine. Public presentments occurred when no landowner could by law be saddled with the costs and were paid by a rate levied on all the inhabitants benefitting from the repairs.¹⁰⁶ This latter type of presentments usually occurred when the repairs exceeded the usual maintenance, or after larger calamities.¹⁰⁷ Both the work of the jurors as well as that of the commissioners was unpaid, although they were allocated some monies from the taxes, to be used for refreshments during their court meetings.¹⁰⁸

This model of administration remained unchanged as long as the sewer commission's area was still predominantly rural, as was the case for the Greenwich Commissioners of Sewers. When an area became more urbanised, the administration moved towards courts of sewers in which the commissioners themselves played a bigger role. This happened over time in the commissions of Westminster, and Holborn and Finsbury, and to lesser degrees in those of Tower Hamlets, and Surrey and Kent.¹⁰⁹

Over the course of the seventeenth century, as their area dealt with a surge of new building developments, the Westminster Commissioners of Sewers appointed salaried officers, including a clerk, a cryer, a bailiff, and several surveyors.¹¹⁰ While the 1531 Bill of Sewers had allowed for these functions to be carried out and paid for from the taxes, it had been hitherto been an ad hoc occupation. In addition, the Westminster Commissioners of

¹⁰⁵ Kennedy and Sandars, *Land drainage and sewers*, p. 86.

¹⁰⁶ Webb and Webb, *English local government*, pp. 60-1.

¹⁰⁷ *Ibid.*, p. 23.

¹⁰⁸ Darlington, 'London commissioners of sewers', p. 286.

¹⁰⁹ Webb and Webb, *English local government*, p. 85.

¹¹⁰ *Ibid.*, pp. 70-2. The bailiff served warrants and summons to court. The surveyor surveyed the walls, ditches, and sewers in the commission and also had to report back on whether repairs were executed.

Sewers organised a permanent standing committee of accounts with a chairman, which took executive decisions. The role of the jury slowly disappeared over time, as they were not present at the meetings of the standing commissions, and by the eighteenth century the jury's duties were rather insignificant. After 1776 the commission developed an even more executive style of management, with additional standing committees for rates and works.¹¹¹ These measures are indicative of a changing organisation as they dealt with an increase in work (specialised committees), as well as increasing sums of money to be raised (permanent salaried officers).

These measures are also evident in other commissions, especially the Surrey and Kent, which at the start of the eighteenth century had administered one of London's most rural areas, that by the later part of the century was rapidly urbanising. Table 3.2 shows the amount of tax that the commissioners raised here, as well as the number of collections they carried out per decade. As the century progressed, the commissioners had to raise money more often, an indicator of the increase in work. It also shows that the amount raised per collection increased over the century, which shows that the alterations they made were more extensive. The 1770s and 1780s, in particular, were busy as a result of rapid urbanisation in this area following the construction of Blackfriars Bridge.

The larger amounts raised were, however, also a result of a change in the way that the commission could collect taxes. In 1771, increasing complaints of nuisance, especially in the Borough (which created a paving commission) led the Surrey and Kent Commissioners of Sewers to obtain powers to make a 'general tax' on the whole district.¹¹² These rates were to be levied on levels, rather than just on those people that directly benefitted from the

¹¹¹ At this date the Westminster Paving Commission had been established, which the Westminster Commissioners of Sewers had to cooperate with. This probably instigated the reorganisation.

¹¹² Webb and Webb, *English local government*, p. 99.

repair of a particular sewer, in order to direct money towards general repairs around the level.¹¹³ As shown in table 3.2 this resulted in larger amounts of tax that the commission raised from each collection in the last three decades of the century, and from this point onwards the commission also gained an increasingly executive structure to manage the flow of money: a standing committee was established, with an expeditor general who was in charge of all income, and who also paid for all works.¹¹⁴ The Holborn and Finsbury sewer commission followed a similar trajectory: as its district became increasingly populous, a permanent salaried collector of taxes was appointed, a reflection of the greater sums that were raised from the rates. In addition, the commission's contracts with workmen became increasingly large in the later part of the century.¹¹⁵

Table 3. 2. Collections in the Surrey and Kent commission.

SKCS	Total raised (£)	Number of collections	£ per collection
1700-09	45.88	5	9.18
1710-19	99.33	9	11.04
1720-29	57.89	6	9.65
1730-39	31.46	4	7.87
1740-49	74.45	8	9.31
1750-59	185.68	14	13.26
1760-69	211.77	13	16.29
1770-79	769.57	15	51.30
1780-89	551.51	11	50.14
1790-99	701.17	17	41.25

Source: Minutes of the Surrey and Kent Commissioners of Sewers, LMA/SKCS/42-56.

The changes in these two commissions show that rather than increasing the duties of obligated parish members, salaried officers began to execute the necessary tasks and were

¹¹³ A level was an area drained by a connected sewer system emptying in the Thames via a sluice. The levels of the Surrey and Kent commission varied in size.

¹¹⁴ Webb and Webb, *English local government*, p. 99.

¹¹⁵ *Ibid.*, p. 78.

paid for their efforts from the rates. In this model, individual householders were no longer required to make repairs themselves but instead had to pay tax for appointed workmen to maintain local sewer banks.¹¹⁶ The more an area urbanised, the more its sewer commission moved towards the 'Westminster model' of administration.¹¹⁷

This was not, however, merely a movement towards greater efficiency: as the jury disappeared, so did the judicial process of the sewer administration. As the commissioners increasingly organised themselves in small executive committees, they became closed bodies, over which the jury exercised little or no control. Their actions became less transparent: tenders were no longer advertised but given to workmen that had connections with commissioners.¹¹⁸ Evidence of cases was no longer presented and heard in an open court.¹¹⁹ Indeed, for much of the eighteenth century, the Westminster sewer commission was administered by varying small groups taken from a pool of many eligible commissioners, and the people who attended to take decisions tended to be those whose interest was at stake.¹²⁰ This led to favouritism towards those landowners and builders who had connections to commissioners, and so could get their estates connected to the drains much quicker.¹²¹ For example, in 1728 Lord Viscount Townshend and Sir Robert Walpole applied for a new sewer in Pall Mall, which the Westminster commission granted even though it had previously denied other people's requests to do exactly the same.¹²² Eventually, the corruption and inefficiency of the commissions became one of the factors

¹¹⁶ E.g. the Kings Scholar Pond Sewer required repairs in 1702. While initially the local landowners were supposed to do it, orders to them were revoked and the Westminster Commissioners of Sewers sent in contracted workmen. LMA/WCS/45 Westminster Commissioners of Sewers, minutes, 27 July 1702.

¹¹⁷ Webb and Webb, *English local government*, p. 84.

¹¹⁸ *Ibid.*, p. 90.

¹¹⁹ Kennedy and Sandars, *Land drainage and sewers*, p. 89.

¹²⁰ Webb and Webb, *English local government*, pp. 74, 76.

¹²¹ *Ibid.*, pp. 81-2.

¹²² Shirata, Y., 'The provision of sewers in west London, 1659-1761' (MPhil. thesis, University of Leicester, 2000), pp. 134-6.

that led to them being considered as outdated institutional bodies by the 1830s, and gave the impetus to the amalgamation of all commissions (with the exception of the City commission) into the Metropolitan Commission of Sewers in 1848.¹²³

Finally, management of the Thames underwent similar changes. Its administration was similar to the rural sewer commissions: Thames Conservancy Courts met separately in Essex, Middlesex, Surrey, and Kent, where jurors made presentments of offences committed in each county. The main issues they dealt with were encroachments on the river (in the shape of platforms, embankments, or wharfs), obstruction to the navigation (such as floating timber, sunken boats, or any kind of rubbish thrown into the water), and offenses against fishing regulations.¹²⁴ Over the course of the eighteenth century, the conservancy courts had to deal with an increasing amount of traffic on the Thames, especially in the Port of London. In response, they intensified their efforts to regulate London's main waterway: while for much of the eighteenth century the courts met three or four times a year but made few, if any, presentments, by the mid-1780s the number of meetings slowed to twice a year, but the list of presentments became more extensive.¹²⁵ In addition, there had been attempts to improve river governance and unify its management under a single administrative body: the Thames Navigation Commission was established in 1751, and consolidated by the 1770 Thames Act to manage the whole length of the Thames. As it was unclear, however, whether it had jurisdiction over the stretch of the river administered by

¹²³ Recently, their actions in the early nineteenth century have been critically re-assessed. See: Hanley, 'Metropolitan Commissioners'; Jefferson-Smith, 'Before Bazalgette'; Sunderland 'London Commissioners of Sewers'.

¹²⁴ See LMA/CLA/36/1/6 to 8 Thames Courts of Conservatory, 1714-1821.

¹²⁵ LMA/CLA/36/1/8 Thames Courts of Conservatory, 1771-1821.

the City of London, this commission did not make any decisions regarding that part of the river, which remained subject to the conservancy courts.¹²⁶

3.5. Conclusion.

Because of a combination of economic necessity (the free-rider problem) and historical precedent, different parts of the water system were administered by different kinds of institutions: drainage remained a public service, while supply came to be dominated by private companies. Although eighteenth-century London's networks of water were managed by very different institutions, they shared some important similarities. Both the companies that supplied the city with water as well as the commissioners that managed its drainage had to cope with an expansion of their work, stemming from the increase in the area that their networks had to cover, as well as the number of people that needed to be connected.

The increase of scale provided both opportunities and challenges for these different institutions. For the companies, expansion allowed them to increase their revenue, which made it economically more attractive to make the investment needed to start a company. New companies therefore emerged whenever there was a sufficient number of people in need of supply to make it financially worthwhile to create a new infrastructure. The increase in size eventually allowed them to issue dividends to their shareholders. Challenges that came with the expansion of their networks referred to the practical issue of how to deliver

¹²⁶ The question of jurisdiction was formally addressed in the mid-nineteenth century, as the establishment of the Thames Conservancy necessitated solving the dispute about who owned this part of the Thames.

water to more people: more water needed to be raised, the network needed to be managed, and as the company expanded a larger workforce was required.

Similarly, the commissioners of sewers had to deal with larger numbers of users connecting to the drainage network, which caused more work, but also allowed them to raise more tax. Over time, they changed their organisation in order to deal with the increase of money to be raised and work to be executed. The changes in administration observed in these commissions reflected a broader transformation in local government practices as they moved from parish-based participant governance to a modernised system of professional officials. This transformation was faster in the newly urbanising areas, and as such indicative of local government's adaptation to the new issues brought about by increasing population density and the transformation of the metropolitan environment.

Neither the water companies or the sewer commissions were new institutions, and the eighteenth century witnessed only part of their trajectory. However, it was the increase in scale that occurred during this century that encouraged them to change and expand in order to better manage London's water. The next chapters deal with the implications of this increase in scale in terms of the expansion of the drainage and water supply networks.

Chapter 4. Drainage, floods, and the expansion of the sewer network.

The process of urbanisation involved major modifications to the physical environment that collectively resulted in higher rates of run-off water, meaning that drainage systems had to be extended.¹ Failure to do so would result in flooding, which as a result of the growth in population affected more people and thus constituted a larger nuisance. As shown in the previous chapter, the sewer commissions, responsible for preventing flooding and facilitating drainage, experienced an increase in their workload over the course of the eighteenth century — an indication of the greater need for drainage management as the built-up area expanded. This management consisted of several key tasks. The physical network had to be extended as more houses required connection to a sewer, meaning that greater quantities of water had to be channelled over longer distances. In addition, the functionality of this network had to be maintained, ensuring sufficient flows of water and preventing blockages. Finally, there was the requirement to balance finances.

The sewer commissions encountered several restrictions that curbed their power to manage eighteenth-century London's drainage. As the providers of a public good, they could not exclude connection to their network, and as a result drainage management often had to be about managing patterns of behaviour regarding the sewers, in terms of use as well as contributions towards maintenance of the system. The main problem that the commissions encountered, however, was that under their original legislation they were only allowed to

¹ These include a variety of alterations: a reduction in infiltration capacity arising from the expansion of the built-up area; the removal of vegetation; changes in topography that involve levelling of the surface; and the construction of sewers and gutters, which can drain water away too quickly for the downstream infrastructure to cope with. Akan, A.O. and Houghtalen, R.J., *Urban hydrology, hydraulics, and stormwater quality* (New York, John Wiley, 2003), p. 1.

maintain the sewers, but not to alter them or construct new ones. This posed particular problems in an expanding city, as it became necessary to turn to other agents in order to construct the network of sewers. The result was a hybrid system of both private and public drains. In turn, this complicated the issue of contribution to the network: both sewer commissions and owners of private sewers had to circumvent the free-rider problem, and ensure that everyone who benefitted from changes contributed to their costs.

The study of London's drainage management is also complicated by the variations in legislation, way of operating, and records kept by the different sewer commissions. In addition, across London the commissions dealt with different issues: some areas experienced a faster rate of urbanisation while others had swampier ground, and these differences affected the kind of work a sewer commission had to focus on. Nevertheless, several problems were encountered across the capital and constituted the main issues that sewer commissions had to address: small-scale flooding, expansion and maintenance of their network, and managing people's contribution towards the works. This chapter explores how these issues were tackled in eighteenth-century London.

4.1. Draining Pimlico.

The interrelation between the tasks faced by the sewer commissions can be illustrated by the case of Belgrave Place in Westminster. This area saw expansion in the number of buildings as well as alterations in water structures made by a private landowner, Chelsea Waterworks. Moreover, this was a low-lying area prone to floods. In the early eighteenth

century the Pimlico area that was eventually to become Belgravia was still mainly unoccupied marshland. Over the course of the next 100 years, however, it was to undergo major changes. In the 1720s Chelsea Waterworks created a series of canals in the lower marshes of Pimlico, while the surrounding fields were either still used as farmland or landscaped into gardens such as those of Chelsea College or the Ranelagh pleasure gardens. The 1746 Rocque map, shown in figure 4.1, depicts this area as fields with trees, crossed by roads and streams, and shows the presence of standing pools of water. In the latter half of the eighteenth century, however, this started to change. The growth of the West End over this time meant that by the 1790s several streets with residential houses had been constructed south of Green Park and to the west of Chelsea Waterworks' canals, as can be seen on the 1790s Horwood map in figure 4.1. Some of the first streets in this area were Belgrave Place and Belgrave Road, located directly to the west of Chelsea Waterworks' canals. The presence of buildings in this area necessitated changes in drainage, and this was reflected in an increase of work for the Westminster Commissioners of Sewers, which administered drainage of these fields. While very few issues are on record for the first 60 years of the eighteenth century for Pimlico, the number of cases the commission had to deal with increased significantly after the late 1760s, an indication of the impact of the new construction.²

In the mid-1790s several builders that were developing Belgrave Road applied to Chelsea Waterworks to construct drains that would feed into a water course on the company's property.³ They complained that as the common sewer, which had previously drained this area, had been partly filled up, the houses in Belgrave Place and along Belgrave Road were

² LMA/WCS/87 Westminster Commissioners of Sewers, index to the minute books, 1659-1806.

³ See e.g. LMA/ACC/2558/CH/1/15 Chelsea Waterworks, minutes, 15 March 1792 and 26 Feb. 1795.

affected by water from ‘land springs’ as well as ‘foul water from their kitchens’, and that their inhabitants experienced frequent flooding.⁴ The request to connect drains was made to Chelsea Waterworks as this company owned the land between the new buildings and the Thames, meaning that any drainage would have to pass across their property. In response, the company went back over its records to investigate how and why Belgrave Place was drained. Their investigation into the flooding and drainage of this area provides examples of the complications that arose when drainage structures changed, the problems inherent in the network, as well as the need to cooperate along the course of a drainage channel.

Figure 4. 1. Belgrave Place on the Rocque and Horwood maps.



The area on the 1746 Rocque map (left) and the 1790s Horwood map (right). A = the location of Belgrave Place, B = Chelsea Waterworks’ infrastructure. The probable location of the disputed drainage structure is indicated in red.

⁴ LMA/ACC/2558/CH/1/15 Chelsea Waterworks, minutes, 5 March 1795.

When Chelsea Waterworks had bought the ground in the mid-1720s, there were only three houses in the area. The company had noted that the land was marshy fields with a few drainage courses emptying in the Thames. There had been a ditch along the road adjoining the waterworks, which drained the area that was to become Belgrave Place as well as the road alongside the waterworks, but the fact that it was referred to as a ditch and not a sewer indicates that it probably did not have flowing water throughout the year. By 1773 the company had realised that the ditch was difficult to clean as it had a very limited fall, again indicating stagnant water. In response, the directors ordered some alterations: the water was diverted into one of the canals made by the company, the ditch was filled up, and by 1785 formed part of a footpath.⁵ It was the stoppage of this ditch that was the cause of the poor drainage experienced by the inhabitants of Belgrave Place. The alteration also meant that all water in the ditch, from the houses and the road, flowed into the company's canals and was eventually distributed to its customers.⁶

Between the 1720s and the 1790s the company recorded that about 170 houses had been constructed in Chelsea and Belgrave Place, all of which except 36 used the ditch as a common sewer in the 1790s.⁷ The greater number of houses meant there was an increase in the amount of water that entered the company's canals, and as there were expectations that more houses would be built between Chelsea Road and Five Field Walk, the company decided it was necessary to stop their drainage and wastewater from entering their supply.⁸ As a result, it was decided that the inhabitants of Belgravia needed a new sewer and the

⁵ LMA/ACC/2558/CH/1/15 Chelsea Waterworks, minutes, 5 March 1795.

⁶ Ibid.

⁷ Ibid.

⁸ Ibid.

company, as well as some of the builders, applied to the Westminster Commissioners of Sewers that the filled ditch should be restored as an ancient waterway.⁹

The case of Belgrave Place showcases most of the issues related to the drainage of the expanding city that the sewer commissions had to deal with, and highlights some of the complexities that plagued London's drainage system in the eighteenth century. First of all, this example shows the need to adapt the natural drainage courses as a result of London's expansion. Builders recognised the need to link new houses to the drainage system and applied to the commissioners to do this. Secondly, it shows the interconnectedness of the network. Chelsea Waterworks, as the landowners of a lower lying area between the West End and the Thames, had to deal with the drainage arising from land higher up than theirs. Thirdly, large sewer systems involve both private and public interests and between these two, tensions could arise. Changes had to be made which affected one landowner, but were mainly of benefit to those at higher elevation. As the city expanded ever greater numbers of people were connected to this network, and the sewer commissions needed to ensure that the collective good of the system was maintained so that those who benefitted from it contributed to those who had to make the changes. Finally, it shows the problems that could arise as result of a lack of proper drainage: because the old drainage ditch was covered up, houses could not drain away their wastewater and their inhabitants complained of flooding, while the company's supplies were affected by wastewater. In effect, water was present in the wrong place, and the sewer commissions had to manage the flow in the watercourses in order to prevent or remedy this situation.

⁹ LMA/ACC/2558/CH/1/15 Chelsea Waterworks, minutes, 5 March 1795.

4.2. Expanding the network: private interest and public needs.

As shown, the complex history of drainage in London involved both public and private elements of the network, which makes it important to understand the relationships between the two. Part of the drainage network had always been private: houses were connected to sewers in the street via a brick drain, which were called 'private drains', and which remained the responsibility of the owners of the house.¹⁰ The sewer commissions, meanwhile, were responsible for the 'common sewer' in the street. When a new house was being built, either its builder or the developer of the plot petitioned their local sewer commission to have the houses drain into the common sewer. When a larger area was being developed, builders and developers had to construct the sewers themselves. These were often worded as 'private drains' as well, even though they could connect anything from two or four houses, or even the property of someone like William Puttney, who applied to connect 166 houses in Brewer Street, Cambridge Street, and Broad Street St James at the same time.¹¹ It was therefore effectively builders and developers that created new sewers, and, while the definitions that commissions used to differentiate between 'drains' and 'sewers' was not quite clear-cut, a privately constructed drain that connected many houses to the network was often referred to as a 'private sewer', as opposed to the common or public sewer.

The private sewers remained the property of their maker. However, as they were connected to the larger public network, they were subject to the jurisdiction of the sewer commissions, which had to regulate the amount of water that flowed through their

¹⁰ Summerson, J., *Georgian London* (Harmondsworth, Penguin Press, 1962), p. 82.

¹¹ LMA/WCS/50 Westminster Commissioners of Sewers, minutes, 1 Feb. 1721/2.

networks. New houses that connected to a private sewer had to obtain permission from both the owner of that sewer as well as the local sewer commission.¹² Sewer owners were not allowed to connect houses without the consent of the commission as, firstly, the commission had to know the amount of water the sewer was processing and, secondly, the connected houses would have to contribute towards that sewer. In order to exert control over the sewers, the Tower Hamlets Commissioners of Sewers, for example, threatened to destroy any private drain into which the owners had allowed other houses to drain.¹³ Conversely, when drains were connected illegally to someone's private sewer, the owner could apply to the commission for help in their removal.¹⁴

Over time, private sewers were built to drain large parts of London, and were particularly prominent in those areas in which the largest building expansion took place: Westminster, the City of London, and as the century wore on, the western parts of Tower Hamlets. By the mid-eighteenth century only a few of the large sewers in the City of London were public, namely the Walbrook, the Moorgate, and the Fleet sewer, while the rest of the network was private.¹⁵ On the other hand, the complexities of construction meant that the distinction between a private and common sewer was often blurred. Not all institutions kept clear records of land use as the Chelsea Waterworks had done, and the absence of records showing which sewers were built by whom could make it extremely difficult to trace who was ultimately responsible for maintenance, repair, and permission to connect. For that reason, unless an owner could be tracked down, the sewer was considered public. In some

¹² See e.g. LMA/WCS/45 Westminster Commissioners of Sewers, minutes, 5 March 1701/2 and 19 March 1701/2.

¹³ LMA/WCS/52 Westminster Commissioners of Sewers, minutes, 12 July 1732; LMA/THCS/11 Tower Hamlets Commissioners of Sewers, minutes, 20 Oct. 1732.

¹⁴ See e.g. LMA/WCS/45 Westminster Commissioners of Sewers, minutes, 30 Nov. 1702.

¹⁵ Fletcher, J., 'History and statistics of the present system of sewerage in the Metropolis', *Journal of the statistical society of London*, 7 (1844), pp. 143-170, p. 157.

cases the commissioners had to resort to individual memory rather than the written word: when in November 1702 William Pannett wanted to connect his house to the sewer in his street he was asked to provide proof that it was a common sewer. In the absence of any definitive documentation elderly residents in the locality were asked to confirm if the sewer had been there for a long time.¹⁶ As the years passed by and particular ownership of a sewer was forgotten, or the owners' family had passed away, a private sewer could pass into public ownership.

This situation presented challenges for those constructing the sewers. Builders not only had to ask permission from the sewer commission to connect to the network, but often had to negotiate with the landowners who owned property along their intended route as well.¹⁷ This was the reason why the builders of Belgrave Place, who were constructing their own drainage for these houses, approached the Chelsea Waterworks for permission to connect to their waterways. In this case the waterworks were quite willing to cooperate with the builders, most likely because they themselves had an interest in the better drainage of these houses, but elsewhere, obtaining permission to connect private sewers was more complex.

The problems were especially intense in the more densely populated areas, where there was less public space through which to run sewers, and where routes had to be negotiated with the multiple owners of private courts, yards, and houses.¹⁸ As a result, individuals could often frustrate the drainage efforts of others, especially if they did not receive any benefit from that particular drain themselves. For example, William Gore, a house owner in courts near Colchester Street, City of London, applied to the City Commissioners of Sewers to construct a private drain to remove spring and wastewater from his cellars and vaults.

¹⁶ LMA/WCS/45 Westminster Commissioners of Sewers, minutes, 2 Nov. 1702.

¹⁷ LMA/WCS/50 Westminster Commissioners of Sewers, minutes, 21 Aug. 1722.

¹⁸ LMA/CLA/6/AD/3/3 City of London Commissioners of Sewers, minutes, 27 Nov. 1702.

Unfortunately, there were houses standing over and adjoining his intended route, the owners of which refused their permission.¹⁹ The inhabitants of these places appealed to the commission that they did not want this drain on the grounds that it would damage their tenements, and the commission decided that William Gore would have to construct his drain another way.²⁰ Gore found a new route that also went through places which were not “Publick streets, lane or common passages”, but in this case it did not have to go through houses and he obtained permission to construct his sewer from these owners.²¹

This, and similar cases, demonstrate some of the difficulties that those who needed to drain their houses encountered. The commissions had little power to force people to comply when it came to private sewers and it was up to the builder or owner to find and negotiate a route, with the commissions merely acting as facilitators. In regard to the public sewers, they could force people to pay a rate, enter their houses to see whether they drained into a sewer or not, or forcibly take their belongings if they refused to pay, but when a sewer was private they had no real power to make people comply. Fortunately, people more often appeared to cooperate in order to ensure better drainage for all concerned: when several developers applied to make drains for a piece of land between Warwick, Glasshouse, Swallow, and Leicester Streets for intended buildings, another developer heard about the plans and proposed to join them so the drain could cross his land between Vine Street and Glasshouse Street, and drain into the Piccadilly common sewer.²² As a result, much of the drainage infrastructure in the expanding areas of eighteenth-century London was constructed by private builders.

¹⁹ LMA/CLA/6/AD/3/6 City of London Commissioners of Sewers, minutes, 30 March 1722.

²⁰ Ibid., 6 and 27 April 1722.

²¹ Ibid., 8 June 1722.

²² LMA/WCS/50 Westminster Commissioners of Sewers, minutes, 1 March 1721/2 and 5 April 1722.

4.3. Floods and flood control.

The main problem experienced by the inhabitants of Belgrave Place illustrates well the need for good drainage infrastructure. Their houses suffered from floods, which were caused both by the high water table in the Five Fields marshlands (the ‘land springs’) as well as by wastewater from their houses (the ‘foul water from their kitchens’). Small-scale flooding, which affected only a few houses or streets, was a common occurrence in eighteenth-century London.²³ In the more built-up commissions it was not uncommon to come across at least ten mentions of flood nuisance a year.²⁴ As the commissions only responded to floods about which complaints were made, it is likely that many more occurred unreported.²⁵ While flooding is to a certain extent unavoidable — every drainage system has a limit beyond which it cannot cope — in many of the cases that resulted in complaints there was an identifiable issue with the sewers. Sometimes this was a defect of the network: for example, when houses in Lombard Street flooded in 1742 it came to light

²³ This section deals with small-scale flash flooding that was generally the result of extreme rainfall and/or defaults in the sewer network. The sewer commissions were also responsible to prevent the larger-scale floods caused by tidal surges on the Thames. These floods, while much more destructive in impact, had a lower frequency and the sewer commission’s attitude to these floods consisted mainly of inspection and maintenance of the river walls. See also: Lieshout, C. van, ‘Floods and flood response in eighteenth-century London’, in J.A. Galloway, ed., *Tides and floods, new research on London and the tidal Thames from the Middle Ages to the twentieth century* (London, Centre for Metropolitan History, 2010), pp. 29-44.

²⁴ E.g. 14 floods in 1742 in the Westminster commission. The same year 15 were recorded in the Holborn and Finsbury commission, and 9 in the City of London. LMA/WCS/53 Westminster Commissioners of Sewers, minutes, 1742; LMA/HFCS/17 Holborn and Finsbury Commissioners of Sewers, minutes, 1742; LMA/CLA/6/AD/3/12 City of London Commissioners of Sewers, minutes, 1742. However, no patterns over time or between commissions can be discerned. See Lieshout, ‘Floods and flood response’, p. 36.

²⁵ See e.g. the relative lack of such mentions in the Surrey and Kent commission, which as a result of its low-lying geography would have been especially prone to floods. It is highly likely that inhabitants of this area did not report every flooding nuisance to its sewer commission; for instance, in 1707 a group of Earl Sluice inhabitants complained to the Surrey and Kent Commissioners of Sewers that they were in great danger of flooding from water coming from the hills, which had frequently happened before. When the commissioners enquired why they had not complained on these previous occasions, the inhabitants responded that they had never received so much damage from the floods before. This indicates that people in a flood-prone area were willing to put up with these floods to a certain extent. LMA/SKCS/42 Surrey and Kent Commissioners of Sewers, minutes, 25 Sep. 1707.

that the sewer causing the problem was at a higher elevation than the cellars it was supposed to drain, which made it impossible for drainage to take place. Other problems arose when gullyholes in the street were too small to convey water to the sewers.²⁶ In other cases the flooding was a result of conflicting uses of the sewer network: certain trades relied on water to power mills and factories, and built penstocks or even diverted sewers for their own use.²⁷ These kinds of issues were resolved by the sewer commissions, which had the power to order blockages to be removed, and were able to take action to repair the sewer in order to ensure a better flow of water.

In many other cases, however, the sewers were blocked as a result of an accumulation of mud or filth, itself usually the outcome of an inadequate fall in the network allowing solid particles to build up in the pipes, but an issue that was also amplified by the usage of the sewers for waste disposal. This created a complex set of problems. The commissioners had two types of strategies to deal with blocked sewers: they could scour and clean them, but also try to prevent solid material from entering the system in the first place. Much of their time was taken up by such measures: of the 63 cases which the Holborn and Finsbury Commissioners of Sewers dealt with in 1772, 37 were associated in one way or another with the prevention of solid matter entering the network, an indication of the difficulties of managing a drainage network that often also functioned as a receptacle of waste.²⁸ Although the disposal of solid waste into the sewers was illegal, it was nevertheless a widespread problem. Many local government bodies tried to legislate against these

²⁶ As happened in Fetter Lane. LMA/CLA/6/AD/3/16 City of London Commissioners of Sewers, minutes, 1 May 1752. The Lombard Street example is from LMA/CLA/6/AD/3/12 City of London Commissioners of Sewers, 22 Oct. 1742.

²⁷ E.g. calico printers made penstocks in a sewer near Old Ford. LMA/THCS/15 Tower Hamlets Commissioners of Sewers, minutes, 28 Oct. 1762.

²⁸ LMA/HFCS/18 Holborn and Finsbury Commissioners of Sewers, minutes, 1772. Most of them were grates. The remaining cases mostly dealt with applications for drains or were related to the collection of taxes.

practices, but usually in vain. Once a problem had arisen, it was notoriously difficult to establish responsibility, and to enforce penalties.²⁹

As is shown in chapter two, there were a good many sources of pollution that included animals, industries, as well as ordinary inhabitants. To deal with them, the commissions summonsed suspected miscreants to their courts to answer charges. For instance, the Surrey and Kent Commissioners of Sewers called up Ralph Thrale for stopping up the sewer with soil from his dog kennel.³⁰ The Tower Hamlets Commissioners of Sewers summonsed Benjamin Truman, owner of one of the largest breweries in London situated in Brick Lane, to explain why hops and grain had been washed from his brewery into the public sewer in the street, causing the blockages that resulted in local flooding.³¹ The City of London Commissioners of Sewers had to cope with sugar bakers who frequently discharged toxic lime waste into the sewers.³² There were complaints of rakers, scavengers, and nightsoilmen leaving waste on the streets, and allowing it to enter the network.³³ Finally, throughout all parts of London, private individuals swept rubbish into the sewers, and the Holborn and Finsbury commission noted in 1742 that it was “the poorer sort of inhabitants” that were particularly guilty of this.³⁴ Preventing solid waste entering the sewer network was therefore an all-consuming task for the commissioners and much of their time was taken up by their efforts to regulate the problem.

The sewer commissions aimed to separate solid waste from liquid drainage, although the latter still included some wastewater. To this end, the commissioners employed different

²⁹ See e.g. Jørgensen, D. ‘Local government responses to urban river pollution in late medieval England’, *Water History*, 2 (2010), pp. 35-52.

³⁰ LMA/SKCS/44 Surrey and Kent Commissioners of Sewers, minutes, 21 March 1731/2 and 20 June 1732.

³¹ LMA/THCS/13 Tower Hamlets Commissioners of Sewers, minutes, 5 March 1741/2 and 23 April 1742.

³² LMA/CLA/6/AD/4/9 City of London Commissioners of Sewers, minutes, 29 Sep. and 15 Dec. 1772.

³³ LMA/THCS/11 Tower Hamlets Commissioners of Sewers, minutes, 24 Nov. 1732; LMA/HFCS/16 Holborn and Finsbury Commissioners of Sewers, minutes, 28 April 1732.

³⁴ LMA/HFCS/17 Holborn and Finsbury Commissioners of Sewers, minutes, 21 May 1742.

strategies, including physical changes to the network, as well as measures to regulate the behaviour of both private citizens and tradesmen.³⁵ In terms of its physical structure, the network was adapted to filter out solids. The basic sewer system already included grates, which functioned to prevent sand and rubbish from entering the network, in cases where the sewers were located below street level. Ralph Thrale, who had been prosecuted by the Surrey and Kent Commissioners of Sewers, was acquitted because he could prove that he had a grate that prevented soil from the dog house entering the common sewer.³⁶ Similarly, Truman was ordered by the Tower Hamlets Commissioners of Sewers to construct a grate in the gateway leading out of the brewery, which would filter the solid waste from the water that was then allowed on the street.³⁷ Maintaining the flow of water by reducing the likelihood of blockages was, at least in theory, a relatively simple matter that entailed little more than some basic civil engineering.

This alone, however, was not sufficient and some further deterrents were needed to dissuade people from blocking the sewers. In this respect, the commissioners sought to impose fines on frequent offenders, as well as encouraging the general public to report illegal uses of the sewage network. For instance, the City of London Commissioners of Sewers, who struggled with ongoing problems with sugar bakers and soap boilers disposing of clay and lime into the sewers, frequently issued fines. While the initial fine for a first offence was 40s, this went up to £5 and then £10 for repeat offenders.³⁸ In addition, they offered financial incentives for witnesses to come forward at the Court of Sewers to give

³⁵ Jørgensen, D., 'Cooperative sanitation: managing streets and gutters in late medieval England and Scandinavia', *Technology and Culture*, 49 (2008), pp. 547-567.

³⁶ LMA/SKCS/44 Surrey and Kent Commissioners of Sewers, minutes, 21 March 1731/2 and 20 June 1732.

³⁷ LMA/THCS/13 Tower Hamlets Commissioners of Sewers, minutes, 2 June 1742.

³⁸ LMA/CLA/6/AD/4/9 City of London Commissioners of Sewers, minutes, 28 April 1772.

evidence against offenders.³⁹ In 1732 a similar incentive was provided by the Tower Hamlets Commissioners of Sewers who ordered that any person giving evidence leading to a conviction of someone for emptying excrement, filth, or soil into the sewers, would be paid ten shillings.⁴⁰ While this reward was not always necessary to persuade people to give evidence — in 1732 inhabitants of Bishopsgate complained to the City Commissioners of Sewers that they had seen Mr Wood pour soil from his house of easement into the sewer without being paid for this information — it could prove an incentive for some individuals to take the time to testify before the court.⁴¹

4.4. Maintenance and costs.

Preventing filth from entering the system through physical means or financial penalties was the favoured course of action, but once there, the sewers had to be cleaned. The maintenance of sewers had traditionally been the responsibility of the landowners.⁴² Over time, and especially in the more urbanised areas, landowners deferred to the sewer commissions to arrange and fund the maintenance of sewers on their land.⁴³ As public authorities, the commissions had the ability to recoup the costs from everyone who benefitted from sewer maintenance, and could force people to contribute. This was executed in two ways: firstly, the commissions charged a fixed fee per new house

³⁹ LMA/CLA/6/AD/4/9 City of London Commissioners of Sewers, minutes, 29 Sep. and 15 Dec. 1772.

⁴⁰ LMA/THCS/11 Tower Hamlets Commissioners of Sewers, minutes, 11 Sep. 1732.

⁴¹ LMA/CLA/6/AD/3/8 City of London Commissioners of Sewers, minutes, 14 Jan. 1731/2.

⁴² See e.g. Jørgensen, 'Cooperative sanitation', p. 558.

⁴³ For example, Lord Romney used to maintain and clean all sewers on his land in Westminster. When this land became increasingly built over he desisted maintaining the sewers, and referred its inhabitants to the Westminster Commissioners of Sewers. LMA/WCS/57 Westminster Commissioners of Sewers, minutes, 24 Jan. 1772.

connected, whether to a private or a public sewer, as each connection entailed an increase in the amount of run-off entering the system, and thus on the possibility of filth entering the system.⁴⁴ Secondly, they charged rates on the houses that benefitted from the repairs or cleaning of a particular sewer. These rates were determined by property value, and could range from three pence to four shillings in the pound, depending on the level of expenditure and the value of land, houses, and premises in an area.⁴⁵ Where rates were charged, they were usually levied on inhabitants occupying houses on a particular level, which was essentially the line of a large leading sewer, and only the people living on that level would pay towards improvements to the local sewers.⁴⁶

The commissions had the power to tax all the inhabitants that benefited from specific works but this was not always a clear-cut issue.⁴⁷ In 1762 the benefit rule was defined as anyone who “might receive benefit by the repair, or injury by the neglect” of a certain sewer.⁴⁸ In practice, however, it was quite often difficult to determine who exactly benefited from repairs, particularly once sewers came to be seen not just as means to protect against flood, but increasingly as a way to drain away surface water. Most commissions operated on the understanding that not only the households connected to the sewers should pay rates, but that all householders in the vicinity of a sewer derived benefit

⁴⁴ This varied and went up as the century wore on: for example, in the Westminster commission the fee per house was 6s 8d in 1722, and 10s 6d in 1792. In the Holborn and Finsbury commission, the fee was 10s per house in 1772. The abovementioned William Puttney, who connected 166 houses, had to pay a total of £63 13s 4d.

⁴⁵ LMA/SKCS/43 Surrey and Kent Commissioners of Sewers, minutes, 4 Sep. 1723; LMA/SKCS/48 Surrey and Kent Commissioners of Sewers, minutes, 21 Sep. 1780.

⁴⁶ Woolrych, H.W., *A treatise on the law of waters, and of sewers* (London, Saunders and Benning, 1830), pp. 408-9.

⁴⁷ Some property was not rated even if it benefited from the sewage works. Examples include all church property, Crown property, Parliament, educational establishments, and law courts. Especially the Westminster commission had a high proportion of these properties. Hanley, J.G., 'The Metropolitan Commissioners of Sewers and the law, 1812-1847', *Urban History*, 33 (2006), pp. 350-68, pp. 364-5.

⁴⁸ C.M., *Laws of sewers*, pp. 13, 15-6.

from drainage and should therefore be liable to pay the rates. The Tower Hamlets Commissioners of Sewers judged that all houses within one mile of a sewer were likely to benefit, although such a rule was not normally followed by the other commissions.⁴⁹

Determining which households benefitted and thus had to contribute towards cleaning or repair was far from straightforward. In built-up areas, drainage structures were not always obvious. For example, some houses drained half into one sewer and half into another, for which the usual solution was to charge them only half the normal rate if the repairs had been on one of those sewers only. In addition, precise knowledge of the system was rarely, if ever, easily available and this, in turn, created the opportunity for householders and businesses to challenge a demand for the rates, since only those benefitting from access to a sewer were obliged to pay. Generally, objectors had to attend the commission's next session and make their case in court. If their claim was upheld, showing, for example, that their premises drained into another sewer, they could either be exempted or receive a reduction in the rate.⁵⁰ Usually they had to provide physical evidence of where the water actually drained, which was by no means an easy task. In 1732, for instance, Elizabeth Romney refused to pay a rate on the Pall Mall sewer as she claimed she had her own private drain. The Westminster Commissioners of Sewers visited her house, but upon opening the drain found that it contained no water, thus suggesting that it flowed elsewhere, in this case into the Pall Mall sewer. As a result, her appeal was rejected and she was instructed to pay the rate: the fact that there was no water in her private drain proved she derived benefit from the common sewer.⁵¹

⁴⁹ Hanley, 'Metropolitan Commissioners', p. 354.

⁵⁰ LMA/CLA/6/AD/3/19 City of London Commissioners of Sewers, minutes, 25 June and 2 July 1762.

⁵¹ LMA/WCS/52 Westminster Commissioners of Sewers, minutes, 26 July, 9 and 13 Aug., and 20 Sep. 1732.

Identifying which individuals were linked to the sewer network was difficult in itself, but given that the sewers were part of a wider system connecting different parts of the city, establishing who was responsible for events that had repercussions elsewhere in the network could also be problematic. In 1782 several Battersea householders appealed against paying rates that had been levied by the Surrey and Kent Commissioners of Sewers for repairs on the Lambeth level. They failed in their request because, although at some distance, their houses nevertheless drained through the Lambeth network of pipes.⁵² Similarly, in 1742, when fishmongers were charged for sewer repairs in the City of London they refused to pay on the grounds that the problem had been caused by an accumulation of mud in a connecting sewer.⁵³ Determining the physical extent of the drainage network was therefore important in determining who precisely was required to contribute. In addition, these cases show that it was up to the commissioners to take a decision on how to balance spreading out the cost of repairs and cleaning across all those who benefitted, whilst at the same time seeking to punish those who polluted the sewer in the first place.

In order to combat the problem of 'free-riders', the commissions had similar powers as Justices of Peace to force people to pay the rates. For example, householders in Tower Hamlets who refused to pay, but could not demonstrate a reason why they should be exempted, were liable to have their possessions confiscated.⁵⁴ Both the City as well as the Westminster Commissioners of Sewers issued warrants of distress against defaulters and on occasion seized goods to recoup revenue.⁵⁵ In the Surrey and Kent commission non-payers

⁵² LMA/SKCS/55 Surrey and Kent Commissioners of Sewers, minutes, 13 March 1782.

⁵³ LMA/CLA/6/AD/3/12 City of London Commissioners of Sewers, minutes, 10 Dec. 1742.

⁵⁴ LMA/THCS/11 Tower Hamlets Commissioners of Sewers, minutes, 17 March 1731/2.

⁵⁵ LMA/CLA/6/AD/3/12 City of London Commissioners of Sewers, minutes, 21 May 1742 and LMA/WCS/52 Westminster Commissioners of Sewers, minutes, 5 Jan. 1731/2.

were threatened with the Exchequer Court.⁵⁶ Those who refused to pay rates could also be blacklisted: in 1722 the Westminster Commissioners of Sewers postponed fixing a burst sewer in St James Park as the Duchess of Buckingham had not paid her rates.⁵⁷ In the same year, householders applying to connect houses near Glasshouse Street to the network were refused permission because the landowner had not paid for connecting his houses in nearby Brewer Street.⁵⁸ Non-payment therefore had consequences for future drainage on one's property.

In the case of private sewers, the duty of cleaning and maintenance fell to the owners of the sewer, although under the jurisdiction of their local sewer commission they could be ordered to clean or repair them. In rapidly expanding urban areas it often happened that many houses benefitted from a private sewer, and at times owners of private sewers approached the sewer commissions to spread the costs. For example, when the northern stretch of a sewer on the westside of Kensington Square had to be cleaned in 1702, the Westminster Commissioners of Sewers ordered the owners of new houses that drained into this sewer to contribute to the cost incurred by the owner, Mr Kemp.⁵⁹ Similarly, when the Long Alley sewer near Moorfields blocked up and caused flooding, local people appointed Mr Emerson, the local landowner, to arrange for the repair. As the costs were estimated to come to £600 he approached the Holborn and Finsbury sewer commission for money from the rates, or at least the means to collect the money "properly" via the commission.⁶⁰ In either case, all those who would benefit by no longer being flooded were made to contribute towards Emerson's work. The commissions therefore were able to enforce

⁵⁶ E.g. LMA/SKCS/44 Surrey and Kent Commissioners of Sewers, minutes, 9 March 1741/2.

⁵⁷ LMA/WCS/50 Westminster Commissioners of Sewers, minutes, 10 May 1722.

⁵⁸ *Ibid.*, 1 March 1721/2.

⁵⁹ LMA/WCS/45 Westminster Commissioners of Sewers, minutes, 19 Feb. 1701/2.

⁶⁰ LMA/HFCS/14 Holborn and Finsbury Commissioners of Sewers, minutes, 11 July 1722.

collectivity if people felt they were paying for a public good and wanted it to be spread out over all those who received a benefit from this.

While they could force people to contribute to the common sewers, the commissions did not have much power over the private sewers, which, again, could cause conflicts. When a private sewer that drained houses in White Alley near Coleman Street needed to be cleaned, its owner, Henry Lovell, required access to the house of William Timbrell, as the sewer passed through his cellar. However, Timbrell refused access as he believed that the drain had mainly been made to benefit the houses in White Alley, and that his house did not receive any benefit from it. As a result, he argued that the drain should not run through his cellar nor should anyone have the right to come into his house to clean it. Lovell took up the case with the City Commissioners of Sewers and claimed that Timbrell benefitted from the sewer, since it carried off spring waters and Timbrell's cellar was the lowest of all houses.⁶¹ While the commission could order the sewer to be cleaned, they could not force Timbrell's cooperation, and in the end Henry Lovell asked and received permission from the commission to make a new drain as Timbrell made too much trouble.⁶² As in the case of William Gore, it was easier to construct a new sewer rather than having to deal with uncooperative neighbouring landowners.

⁶¹ LMA/CLA/6/AD/3/8 City of London Commissioners of Sewers, minutes, 24 March 1731/2.

⁶² LMA/CLA/6/AD/3/9 City of London Commissioners of Sewers, minutes, 30 June and 7 July 1732.

4.5. Conclusion.

This chapter has shown how an institution, meant to deal with the *status quo*, struggled to cope with the changes to drainage inherent in the processes of urban growth. The sewer commissions were equipped to deal with the prevention of floods by cleaning and maintaining sewers, and were able to recoup the costs through the rates. However, in a situation where there were no existing sewers to clean, floods could only be remedied by the creation of new drains prior to development, and here the commissions reached the limits of their authority. The limitation of the sewer commissions' power under their Tudor statutes prohibited them from building new sewers, necessitating the cooperation of private builders and developers. In the process of this expansion, a network of public and private drains and sewers was built up haphazardly over time, resulting in an exceedingly complex system that was both difficult to administer and almost impossible to know.

While this solution was successful in the sense that new sewers were being constructed as the city expanded, the reality of a network in which parts were owned privately, and other parts were public, made its management exceptionally complex. As some of the examples show, builders and house owners had to negotiate their own sewers, and as the interest of private property remained paramount in eighteenth-century England, this was not always easy. The Belgrave Road inhabitants were fortunate: as their drainage created problems for Chelsea Waterworks in the long term, it benefitted the company as much as the inhabitants to cooperate and make a sewer. In other cases, it was generally easier to find a new route rather than forcing this cooperation to occur.

The commissioners of sewers operated in a context of increased scale — a growing network and the need to connect more people over a wider area — and had to balance this with the management of the physical infrastructure and the desire, if not the requirement, to maintain financial balance. The restrictions they encountered were part of their institutional limits as public authorities operating under outdated statutes. The other institutions managing London's water, the water companies, suffered neither of these limitations, and were able to both construct their own infrastructure as well as exclude people from their service. The challenges they encountered in this and the impact this had on eighteenth-century London's water management is the topic of the following chapters.

Chapter 5. Expanding the supply network: geography, technology, and water management.

An expanding city and growing population presented enormous challenges as well as opportunities for the water companies, both in terms of having sufficient supplies available as well as distributing it to their customers. The companies reacted in specific ways, depending on the spatial configuration of their intake points and customer bases, their financial situation, threats from competitors as well as the demands for water itself. This chapter explores this set of issues, focusing on the structural problems affecting the availability of water and the quality of supply in the context of an expanding infrastructure network. These structural problems were exacerbated during periodic shortages arising from natural phenomena, such as drought, which often forced the companies to take action to maintain or enhance their supply.

Expanding technological systems are often hit by a reverse salient: problems with a particular component in the system that hampers the whole enterprise.¹ These constraints are often technological or material in nature, but can also emerge because of environmental, financial, or legal factors. The main reverse salient in the water supply system during the eighteenth century was the machinery and the associated costs of raising sufficient water, which affected the number of customers that could be reached, as well as the areas that individual companies could supply. As the geographical limits of the customer base extended farther away from the Thames, water had to be raised higher, and

¹ Hughes, T.P., *Networks of power: electrification in western society, 1880-1930* (Baltimore, Johns Hopkins University Press, 1993), p. 79.

transported farther away. Innovation in water-raising technology therefore became increasingly important for many of the companies if they wanted to expand their business.

This chapter explores the ways in which the companies managed expansion of their networks, with a particular focus on the geographical factors that determined the different strategies available to individual companies. Firstly, it examines the basic components of the water infrastructure, noting differences arising from geographical factors. Secondly, it explores how water was supplied to the emerging West End, an area where the geographical constraints were particularly evident but which, crucially, also had the pull-factor of wealthy inhabitants with sufficient purchasing power to encourage the provision of a commercial water supply. Next, the chapter examines innovations in water-raising technology, which allowed the companies to overcome, to a certain extent, the main reverse salient in their supply network. New technologies were adopted by different companies at different times, depending on their needs, financial constraints, and managerial choices. The last section examines how companies regulated the water in their network in their efforts to balance a limited supply of water with growing consumer demand.

5.1. Water infrastructure.

Broadly speaking, the general structure of the supply network was very similar for all water companies. Each had at least one water-tower or reservoir in which they collected and stored the water before it was discharged into wooden pipes and distributed using

gravity as the driving force. A sufficient volume of water in these reservoirs and towers was necessary in order to maintain pressure throughout the network, which could also be used to even out fluctuations in the supply. Whether a company used a tower or a reservoir depended on its location: companies that supplied from the city's edges, such as the New River Company and Chelsea Waterworks, had sufficient space to construct reservoirs. By contrast, companies that were located within the built-up area, such as London Bridge and York Buildings Waterworks, shown in figure 5.1, were forced by reasons of cost and lack of space to use water-towers.

Figure 5. 1. York Buildings Waterworks, c. 1755.



Engraving by John Boydell. Source: © Trustees of the British Museum.

The first challenge that the companies needed to overcome was filling their reservoirs with water. The New River Company supplied its reservoirs via a 40-mile canal from springs in Hertfordshire, but for all other companies it was a matter of raising water, a task they

accomplished using different technologies. London Bridge Waterworks raised water by means of a waterwheel that was turned by the currents forced through the narrow locks of Old London Bridge. By the early eighteenth century this engine had been replaced and a new main wheel had been constructed by the engineer George Sorocold. It raised Thames water into a cistern on the water-tower, which is pictured together with the wheel in figure 5.2.² Once built, this engine ran on waterpower alone and so was a relatively cost-effective means of raising water.

Figure 5. 2. London Bridge Waterworks, c. 1749.



Print by Samuel and Nathaniel Buck. Source: © Trustees of the British Museum.

² Dickinson, H. W., *Water supply of Greater London* (London, The Courier Press, 1954), p. 24.

However, engines like these were only of use in places which had a strong flow of water, and had their drawbacks. London Bridge Waterworks was reliant on the Thames, with all the uncertainties that this brought. The company was unable to supply water for six out of 24 hours and it also suffered during low neap tides as the section of the Thames from which it drew water ran dry.³ Chelsea Waterworks also partly relied on a tidal waterwheel, which was turned by water that had been drawn into its system of canals at high tide to be released at a lower tide, and faced similar issues: in the 1740s, for example, customers complained that they only received water at irregular and inconvenient hours.⁴

Most of the other early companies that were not situated at a convenient location for a waterwheel, such as Shadwell and York Buildings Waterworks, were forced to use other means to raise water. Their technological solutions included horse engines as well as those powered by steam — mechanisms that were more costly to run. Unlike a waterwheel, horses needed to be fed, rested, and cared for, and a set of horses could only lift a limited amount of water. As a result, over the course of the eighteenth century most of the waterworks eventually moved to steam power (figure 5.1 shows the steam of York Buildings Waterworks' engine). The steam engine's development was from its birth closely related to raising water, and waterworks became, after mining, the main early users of steam technology.⁵ The point at which a particular company changed from horse to steam power depended on many factors, which are explored in more detail below.

³ Mylne, R., letter in the *Public Advertiser* of 10 July 1767; Ward R., *London's New River* (London, Historical Publications, 2003), p. 231.

⁴ LMA/ACC/2558/CH/1/10 Chelsea Waterworks, minutes, 10 June 1743.

⁵ Kanefsky, J. and Robey, J., 'Steam engines in 18th-century Britain: a quantitative assessment', *Technology and Culture*, 21 (1980), pp. 161-86, p. 181. The term 'steam engine' is used throughout this chapter even though the earlier ones were technically atmospheric engines. Contemporaries referred to them as 'fire engines'.

From the water-towers and reservoirs the water was distributed through a network of wooden pipes. The most common form for these pipes was to connect eight-feet-long wooden trunks that had been bored through by hammering the pointed end of one trunk into the next one.⁶ As this technique meant that only one approximate size pipe was possible, groups of trunks were used where larger pipes were necessary, as shown in figure 5.3. This image depicts the pipes on the surface, but pipes running along streets were sunk underground where they were protected from frost and damage by traffic. Nevertheless, one of the companies' main costs involved replacement of the pipes, since the wood rotted after a certain number of years, ranging from four to 25 years depending on ground conditions and the type of wood used.⁷

Figure 5. 3. Water infrastructure: New River Company's main.



Source: Islington Local History Centre.

⁶ Roberts, G., *From Chelsea to Cairo, Taylor-made water through eleven reigns and in six continents* (London, Thomas Telford Publishing, 2006), p. 44; Ward, *New River*, p. 52.

⁷ Ward, *New River*, pp. 51, 53.

The pipe network was made up of a system of mains and services. The mains, which generally consisted of several pipes grouped together, such as those in figure 5.3, were directly fed from the reservoirs and from there led into the neighbourhoods supplied by the companies. Attached to each main were several services, which distributed the water through a smaller area or single street. Services were generally smaller than mains, although they varied in size. Individual houses connected to these services, or occasionally directly to the mains, via leaden branch pipes, which were the property of the customer that received the water.⁸

At the interconnection between each service and the main was a brass or iron turncock, which could be turned by a key. As there was insufficient pressure to fill the entire network at the same time, each service only contained water at certain days and times, according to a schedule. Early leases of the New River Company indicate that it promised to supply at least three days a week, and evidence suggests that during the eighteenth century it was still normal to be supplied every other day.⁹ When a service was scheduled to receive water, a company employee (also called a turncock) switched it on. Most houses did not have a stopcock at the end of their pipe, and thus the water would run constantly throughout the time that their service was switched on. For this purpose customers had cisterns in their premises, which were usually situated on a low level as the pressure in the pipes was insufficient to allow the supply to reach higher storeys.¹⁰ When the time was up, the turncock would switch off the service to redirect the water to the next set of pipes, which

⁸ Roberts, *Chelsea to Cairo*, p. 44; Ward, *New River*, p. 54; LMA/ACC/2558/CH/1/2 Chelsea Waterworks, minutes, 21 Sep. 1726.

⁹ Ward, *New River*, p. 58; LMA/ACC/2558/CH/1/1 Chelsea Waterworks, minutes, 17 March 1726.

¹⁰ Roberts, *Chelsea to Cairo*, p. 46.

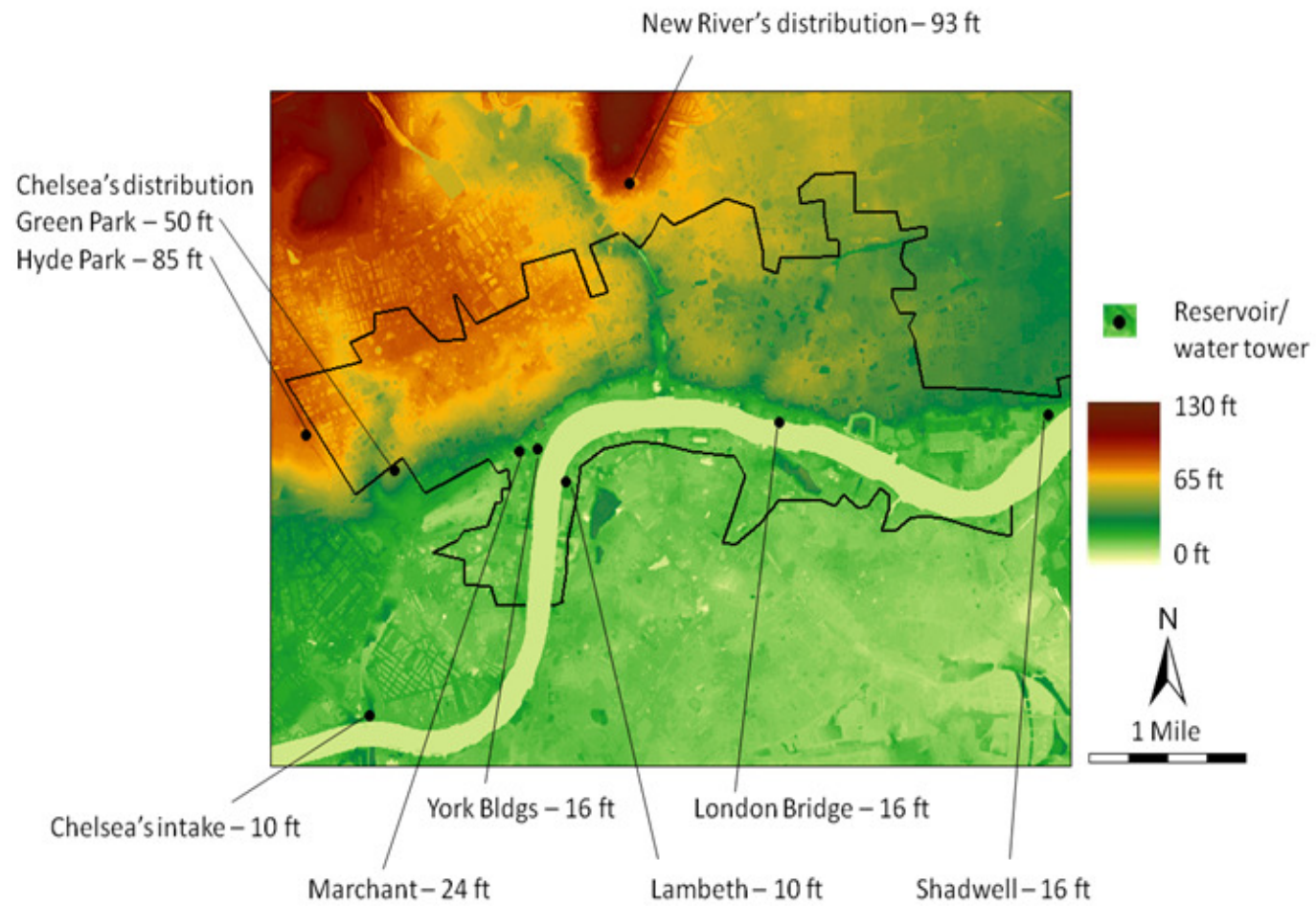
would in turn be supplied for a specified period of time.¹¹ The amount of water that customers received during this time therefore depended on several factors: the length of time that their service had been switched on, the pressure in the pipe, and the size of their own branch pipe. Adjustments to amounts of water that consumers received could be made by changing one or more of these factors, and they played an important role in the way that the water companies managed supply.

5.2. Geographical and environmental constraints.

While the distribution system was essentially the same for all companies, they each had particular problems to overcome as a result of different geographical conditions. Depending on the location of their intake points and the geographical spread of their customers, all companies had different constraints that hindered their supply. Figure 5.4 shows a digital elevation model with the locations of the companies' intake and distribution points. From this evidence, some of the structural problems each company faced become clear. The majority of the companies used the Thames as their source, and so their intake points were located at its banks, well below the elevation of most of their customers. In these situations, companies had to pump their water uphill and their ability to do so depended on the pressure from their water-tower, which in turn determined the spatial reach of their distribution network.

¹¹ The time required to fill each customer's cistern had been ascertained and the turncock was not allowed to leave the service on for longer. Turncocks were instructed to open the pipes of the next service before closing those of the previous one, in order to avoid blowing up the wooden pipes. *Minutes of evidence taken before the select committee on the supply of water to the metropolis*, PP 1821 (706), pp. 5, 180.

Figure 5. 4. Intake and distribution points of the water companies.



Based on: Lindberg and Grimmond (2011).

The only way to provide a supply to customers at higher elevations than this limit was to raise the water to a distribution reservoir that was at a similar level, and distribute from there. This was the solution adopted by Chelsea Waterworks, which pumped water into reservoirs in Hyde and Green Parks. Here it was raised again into water-towers so that sufficient pressure to supply throughout the West End could be achieved. For the Thames-based companies, as the spatial reach of their customer base spread farther away from the river, both the distance and the height that needed to be bridged increased and water-raising technology became increasingly important. Not surprisingly, it was these companies that experimented earliest with modern technology.

By contrast, a few companies had their points of intake from springs and streams at a higher elevation, notably the New River Company and Hampstead Waterworks (located farther north than the data shown in figure 5.4).¹² As many of the customers supplied were located at lower elevations, these companies were at a financial advantage since their water could be gravity-fed, and therefore they had less need to invest in expensive technology.

Another way in which the location of reservoirs mattered was for the companies' expansion strategies. Companies located at the edges of the city could find new customers by supplying the buildings on the expanding urban periphery, while those closer to the river that were hemmed in by adjoining rivals could not develop a new customer base without competing against other companies. Both York Buildings and Shadwell Waterworks found themselves in this position, forced to supply uphill from the Thames whilst becoming increasingly confined to a relatively small area as a result of being hemmed in from the north by the New River Company and West Ham Waterworks respectively. London Bridge

¹² There was also Hyde Park Waterworks, until it was taken over by Chelsea Waterworks in the early 1720s. West Ham Waterworks took its supply from the river Lea, but this was fairly level with its customer base and thus did not provide a geographical advantage. West Ham Waterworks used a horse engine.

Waterworks, which was in a similar position, eventually decided to focus on expansion to the south, over London Bridge, as it recognised that it could not compete against the New River Company for customers in the City.¹³ Geography was therefore a key factor that influenced which structural problems each company faced as they attempted to manage their expanding networks.

Over and above these geographical determinants, another factor that needs to be taken into account in understanding how companies responded to fluctuations in demand and supply is London's climate. The structural problems noted above were often exacerbated during times of scarcity brought about by drought, which not only heightened dependence on other sources, but also put pressure on the water suppliers to better manage their own stocks. Often, new forms of water storage and distribution were introduced at these times in order to maintain supply through the network in times of a shortage.

There were several periods of drought during the eighteenth century which impacted on London's water supply. While there are no consistent instrumental weather observations available before 1841, a few recorded precipitation series from various places in and around London have survived.¹⁴ These measurements were sporadic and not always comparable, although they improved for the second half of the eighteenth century as interest in the recording of natural events grew.¹⁵ B.G. Wales-Smith has developed logarithms to connect these records into a single comparative running series that can be used to compile an overview of rainfall over the century, which has been depicted in figure 5.5.¹⁶ This graph

¹³ LMA/ACC/2558/LB/1/4 London Bridge Waterworks, minutes, 14 Nov. 1794.

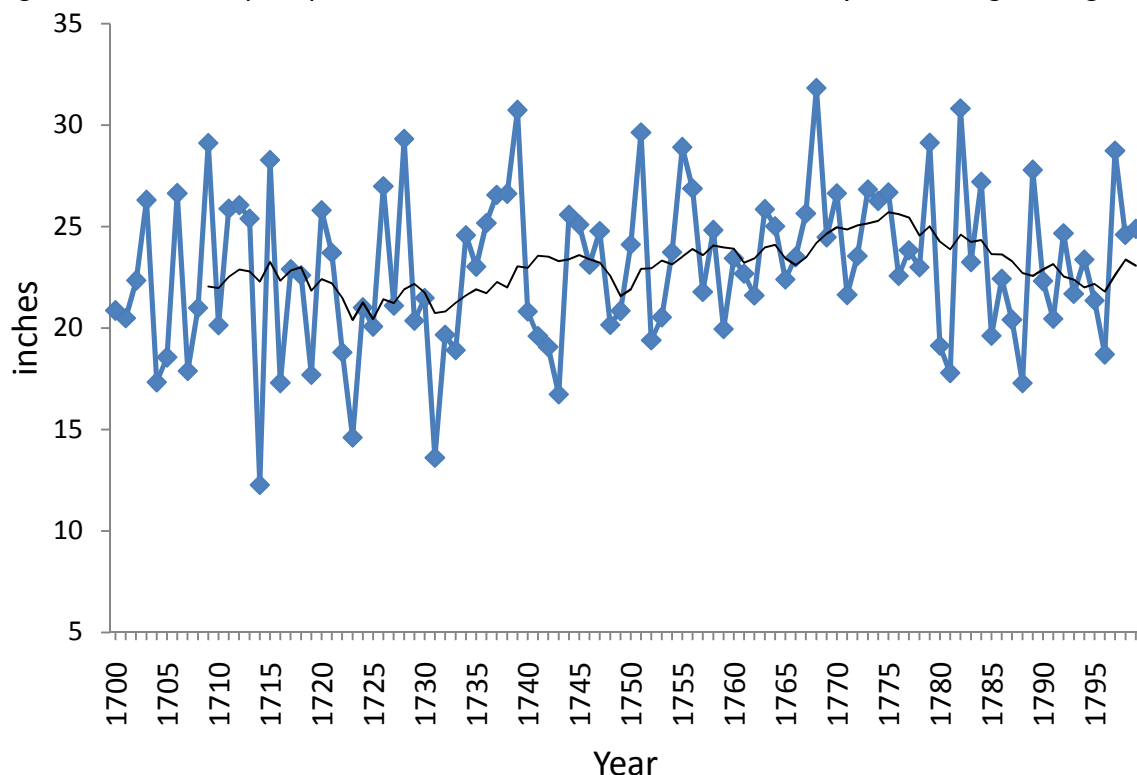
¹⁴ Brazell, J.H., *London weather* (London, Meteorological Office, 1968), p. 1.

¹⁵ Golinski, J., *British weather and the climate of Enlightenment* (Chicago, University of Chicago Press, 2007), p. xiii.

¹⁶ Wales-Smith, B.G., 'Monthly and annual totals of rainfall representative of Kew, Surrey, from 1697 to 1970', *Meteorological Magazine*, 100 (1971), pp. 345-362.

shows that there were significant variations from year to year but also that there was a gradual trend towards wetter conditions over the century. There were several clusters of dry years between the 1710s and 1730s, after which a general pattern emerged during the 1760s and 1770s with more precipitation but fewer extreme years.¹⁷ The last two decades of the century showed a more erratic pattern of rainfall, with very wet years followed by very dry ones. Figure 5.6 focuses on the drier periods based on the years which received less than 15 per cent of the centennial mean. While dry years occurred throughout the century, they were notably absent during the wetter period of the mid-1750s to the 1770s. Especially in the first half of the century several drought clusters can be observed, some of which had an important impact on London's water market.

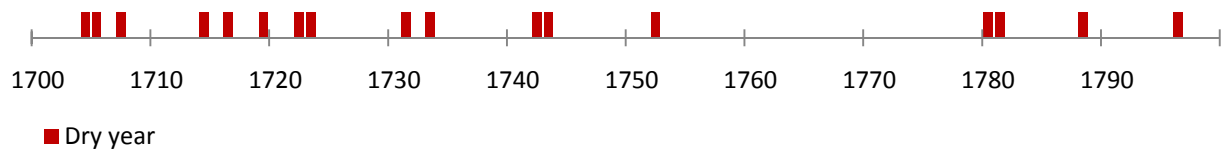
Figure 5. 5. Annual precipitation in London, 1700-1799, with a 10 year moving average.



Based on: Brazell (1968) and Wales-Smith (1971).

¹⁷ See also Brazell, *London weather*, p. 4; Lamb, H.H, *Climate, history, and the modern world* (London, Methuen, 1982), pp 231-6.

Figure 5. 6. Dry years in eighteenth-century London.



Based on: Brazell (1968) and Wales-Smith (1971).

The fluctuations in rainfall impacted more severely on the companies that drew their water from springs than on those that used the Thames, as the water-table beneath the chalk hills that surround the London basin was directly related to the level of precipitation. Wetter weather significantly raised this water-table and as a result during wetter periods an increase in land springs was noted.¹⁸ Wetter periods therefore especially benefitted the companies relying on springs to the north of London, which, inversely, suffered most during drier years. All companies were to some extent affected by droughts, however, mainly because the fall in the water-table encouraged more people to turn to them for supply, as wells and springs became less reliable. During the drought of the early 1730s Chelsea Waterworks had been forced to turn away people who applied for a commercial water supply, as it could not provide enough water for more customers.¹⁹ However, its directors also noted that “the several Water Companys whose Dependance is on the Rise of Springs will be greatly distressed for Water” as a result of the same dry weather, and decided that it would “be of great Advantage to the Company if they shall make timely Provision of Water for the next Summer, not only the better to supply their present Tenants but also to serve

¹⁸ Brooks, C.E.P. and Glasspoole, J., *British floods and droughts* (London, Ernest Benn Limited, 1928), p. 85.

¹⁹ LMA/ACC/2558/CH/1/5 Chelsea Waterworks, minutes, 21 June 1733; 25 Sep. 1733.

several others”.²⁰ Fluctuations in weather patterns could therefore provide a competitive advantage, if the company managed to improve its supply.

The interplay between geographical factors, climatic influences, and changes in the customer base was therefore complex. To understand these complexities better, the following section focuses on one area supplied by companies with both a river-based source and also spring-fed supplies: the emerging West End.

5.3. Supplying the West End: canals versus engines.

London’s expansion in the late seventeenth and early eighteenth centuries was especially evident in the north-western part of town. This area contained a relatively large proportion of wealthy inhabitants, many of whom wanted a piped water supply.²¹ However, there were some geographical constraints that limited supply, which were exacerbated as the city expanded farther towards the north-west. As can be seen in figure 5.4, the West End was already at a higher elevation compared to the rest of the city and expansion took place at even higher levels as well as farther away from the Thames. This meant that for the Thames-based companies of the early eighteenth century, Marchant’s Waterworks and York Buildings Waterworks, both the height the water needed to be raised and the distance that it had to be transported grew.

²⁰ LMA/ACC/2558/CH/1/5 Chelsea Waterworks, minutes, 25 Sep. 1733.

²¹ Bromehead, C.E.N., 'The influence of its geography on the growth of London', *Geographical Journal*, 60 (1922), pp. 125-35, pp. 132-3; Spate, O.H.K., 'The growth of London, A.D. 1660-1800', in H.C. Darby, ed., *An historical geography of England before A.D. 1800* (Cambridge, Cambridge University Press, 1936), pp. 529-48, pp. 540-1.

Even the New River Company did not have the advantage here that it had in the City: in order to reach the West End from the New River Head, its pipes had to bridge the Fleet ditch (depicted as the green strip of land in the yellow higher areas of figure 5.4). This meant that the force of gravity from its main reservoir was inadequate to maintain sufficient pressure to transport water through the pipes to the western end of town — a problem that led the company to consult various engineers, including Sir Christopher Wren.²² Eventually, in 1708, the company constructed an additional reservoir situated at a higher elevation than the New River Head, which provided more gravitational force to transport the water farther away.²³ The difference in height between these reservoirs is visible in figure 5.7, which shows the new reservoir in the foreground and the New River Head slightly below.

Figure 5. 7. The New River Company's reservoirs, 1752.



A = New River Head. B = the new reservoir. Printed and published by John and Thomas Bowles. Source: © Trustees of the British Museum.

²² Ward, *New River*, pp. 123-4.

²³ Dickinson, *Water supply*, p. 38.

One of the main rivals to the New River Company was Hampstead Waterworks, which was able to supply the West End north of Piccadilly at a relatively high pressure. However, because of its complete dependence on springs in Hampstead Heath, it only had limited supplies and was therefore unable to expand its market area.²⁴ Similarly, Hyde Park Waterworks was only able to supply around 400 houses in the late seventeenth century as it, too, relied on springs.²⁵ The West End's structural shortage of sufficient water to satisfy its demand therefore created the economic conditions for either a new company to emerge, or for the existing companies to invest in additional infrastructure.

The dry years of the late 1710s and early 1720s proved particularly difficult for spring-based companies and this became the catalyst for several plans to improve supply to this area. The dry summer of 1716 had left many of Hampstead Waterworks' customers without water, and forced its managers to seek a solution. They enlarged their ponds, which would enable the company to store more water and regulate the service better.²⁶ Of greater significance, however, was the emerging problem of supplying the West End, which was also exacerbated by the dry conditions. In 1725, Sir John Vanbrugh noted that in the previous years the Hyde Park springs had failed as a result of the dry weather, thus leading to acute water shortages in the West End.²⁷

These conditions provided the impetus for plans to bring more water into London from the river Colne, which flowed to the west of the city passing by St Albans and Uxbridge to join the Thames near Staines. An enterprising gentleman named Thomas Acherley had noted the increase in demand for water during the 1716 dry summer, and made a survey of

²⁴ Ward, *New River*, p. 110.

²⁵ Westminster Archives, F2489, Hyde Park Waterworks, list of tenants, 1678.

²⁶ TNA/T/1/248 Treasury Board, papers, July-Dec. 1724, p. 30.

²⁷ TNA/T/1/252 Treasury Board, papers, Jan.-May 1725, p. 64.

the Colne in order to assess the feasibility of diverting part of it to London. He discovered it had both a sufficient fall and rapidity to provide water to the city, and petitioned Parliament in 1719 to adopt his plans. He linked the need for a new water company explicitly to the growth of the West End, and mentioned the success of Hugh Myddleton's New River Company, established a century previously.²⁸ Acherley claimed that the people who wanted water in the 1720s were as numerous as they had been a hundred years before, and that since London and Westminster had grown so much, "a plentiful stream at affordable rates will be necessary".²⁹ However, while his plans were a solution to the structural problems of London's growth and the increasing demand for piped water, the catalyst had been a particularly dry summer.

Perhaps mindful of the threat of a new competitor, the existing companies also tried to satisfy the demand for water in the West End. For York Buildings Waterworks, which had been supplying Westminster and St Martin-in-the-Fields since 1675, the newly developed areas were located in the company's natural expansion area, directly beyond the buildings it already supplied. In order to be able to reach customers at this higher elevation, however, the company required better water-raising technologies. New machinery of this kind was mainly developed as a way of improving drainage in mines. One of the earliest available machines that did this was the Savery engine, nicknamed the Miner's Friend, which was technically not yet a steam engine but a vacuum pump. Possibly as early as 1712 York Buildings Waterworks decided to build a Savery engine, which was definitely installed in 1714.³⁰ Unfortunately the engine was still experimental and proved inadequate and

²⁸ House of Commons Journals, XIX, p. 284.

²⁹ TNA/T/1/248 Treasury Board, papers, July-Dec. 1724, p. 30.

³⁰ Stewart, L., *The rise of public science: rhetoric, technology, and natural philosophy in Newtonian Britain, 1660-1750* (Cambridge, Cambridge University Press, 1992), p. 291.

unreliable, and as a result it was soon abandoned.³¹ In 1719 the company was taken over by a group of investors led by Case Billingsley, as discussed in chapter three. Billingsley, who showed an interest for scientific and technological challenges, saw the technical difficulties of his new company as an investment opportunity.³² He and the other investors also had interests in several mining companies, which provided them with the up-to-date technological knowledge of raising water as well as, crucially, a cheap supply of coal. They made plans to build a Newcomen-style engine in 1724.³³

Another of the new investors in the company, John Brydges, the Duke of Chandos, played an equally important role in York Buildings' desire to supply the West End. Chandos owned land near Cavendish Square, and was instrumental in developing around 6,000 new houses during the early eighteenth century, which he planned to supply with water by constructing a reservoir on his property.³⁴ For him, supplying this area promised a twofold return: additional profit arising from extra customers supplied by the York Buildings Waterworks, and the possibility of attracting new tenants for the properties on his estate. The elevated West End location as well as the potential for 6,000 new customers would be advantageous for any water company, and both the Colne instigators as well as the New River Company expressed their interest to Chandos about a Cavendish Square reservoir.³⁵ However, while he considered their proposals, Chandos preferred to deal with York Buildings Waterworks, as he would benefit from a share in the profits.³⁶

³¹ Dickinson, *Water supply*, p. 60.

³² Among other projects, he tried to solve the problem of accurately measuring one's longitude at sea. Stewart, *Rise of science*, pp. 291-2.

³³ Stewart, *Rise of science*, p. 291.

³⁴ *Ibid.*, p. 328.

³⁵ *Ibid.*, p. 351.

³⁶ *Ibid.*

In order to draw a sufficient supply of Thames water for a reservoir near Cavendish Square a water-raising engine would be essential. Chandos employed the engineer John Theophilus Desaguliers to consult on the company's steam engine.³⁷ Using his designs an engine was raising water by 1726, defying public opinion on the improbability that 'the York-Buildings Dragons' would work.³⁸ Mechanically it was a success, and indeed allowed the company to supply the reservoir near Cavendish Square, 60 to 70 feet higher than its intake point.³⁹ Unfortunately the 'dragon' proved very expensive to run. Even with the coal coming from company-affiliated mines, transport to London meant that it cost eight times as much as it did in the coal-mining areas where the steam engines had been developed, and as a result the engine did not provide any financial benefit to the company.⁴⁰ For this reason the engine was shut down in 1731 and, as it could no longer raise water to the Cavendish Square area, York Buildings Waterworks was forced to give up its upper reservoir as well.⁴¹ In 1733 it was announced in the *Daily Journal* that the New River Company would buy it — a victory for gravity-fed supply over that drawn from the Thames.⁴²

Meanwhile, after having been discussed during several sessions of Parliament between 1719 and 1722, plans to supply the West End from the Colne also ran into difficulties.⁴³ Rival plans competed for attention: Thomas Acherley's original ideas were joined by another scheme proposed by a Mr Blackmore, but in the aftermath of the South Sea Bubble collapse

³⁷ Stewart, *Rise of science*, pp. 238-240.

³⁸ Anonymous, *The York-Buildings Dragons* (London, 1726).

³⁹ *Select committee*, PP 1821 (706), p. 25.

⁴⁰ Stewart, *Rise of science*, p. 358; Allen, R., *The British Industrial Revolution in global perspective* (Cambridge, Cambridge University Press, 1992), p. 82.

⁴¹ Buchanan, R.A. and Watkins, G., *The industrial archaeology of the stationary steam engine* (London, Allen Lane, 1976), p. 11; Stewart, *Rise of science*, p. 359.

⁴² *Daily Journal*, 11 July 1733.

⁴³ Journals of the House of Commons, XIX, p. 284 to XX, p. 418.

neither was able to raise sufficient funds to proceed.⁴⁴ There were also objections that hindered the schemes' passage through Parliament.⁴⁵ Millers downstream from the intended intake were afraid that there would be less water left in the river for them to run their mills.⁴⁶ In addition, there were concerns that if part of the Colne was diverted to London and would no longer discharge in the Thames at Staines, this would lower the water-level of the Thames itself. It was believed that there were several shallows in the river up to the place where the Colne joined the Thames and that the extra supply improved its navigation. Threats to this resulted in objections from barge-owners and landowners concerned about the navigation, who believed that the river was already too shallow, and if water was to be diverted navigation would even become more difficult, and as a result goods traded on the river would become more expensive.⁴⁷ Despite evidence from several surveyors, including Desaguliers — who was of the opinion that the new buildings were in need of water — that this would not be the case, neither Acherley's nor Blackmore's plans were granted permission to go ahead.⁴⁸

While there was an increasing demand for commercial water in West London during this period, there were many obstructions to efforts to raise water to this elevation and distance from the Thames. The Colne plans were inhibited by concerns that taking water from here would disadvantage people at its source, while the improvements of York Buildings Waterworks were curtailed by the inadequate technology at the time which could not overcome the company's geographical constraints. By the end of the 1720s, therefore, plans

⁴⁴ TNA/T/1/248 Treasury Board, papers, July-Dec. 1724, p. 30; Dickinson, *Water supply*, p. 45.

⁴⁵ Journals of the House of Commons, XIX, p. 284 to XX, p. 418.

⁴⁶ Journals of the House of Commons, XIX, p. 315. The millers were backed by the nearby towns, St Albans and Uxbridge, which contained many of the bakers that depended on this industry. *Ibid.*, pp. 580, 592.

⁴⁷ Journals of the House of Commons, XIX, pp. 568, 580, 584, 587.

⁴⁸ *Ibid.*, pp. 603-4.

to supply the West End either by the York Buildings Waterworks or by a new company using Colne water had come to nothing and it was the New River Company, which had a geographical advantage through its higher reservoir, that was able to expand throughout the northern parts of the West End.

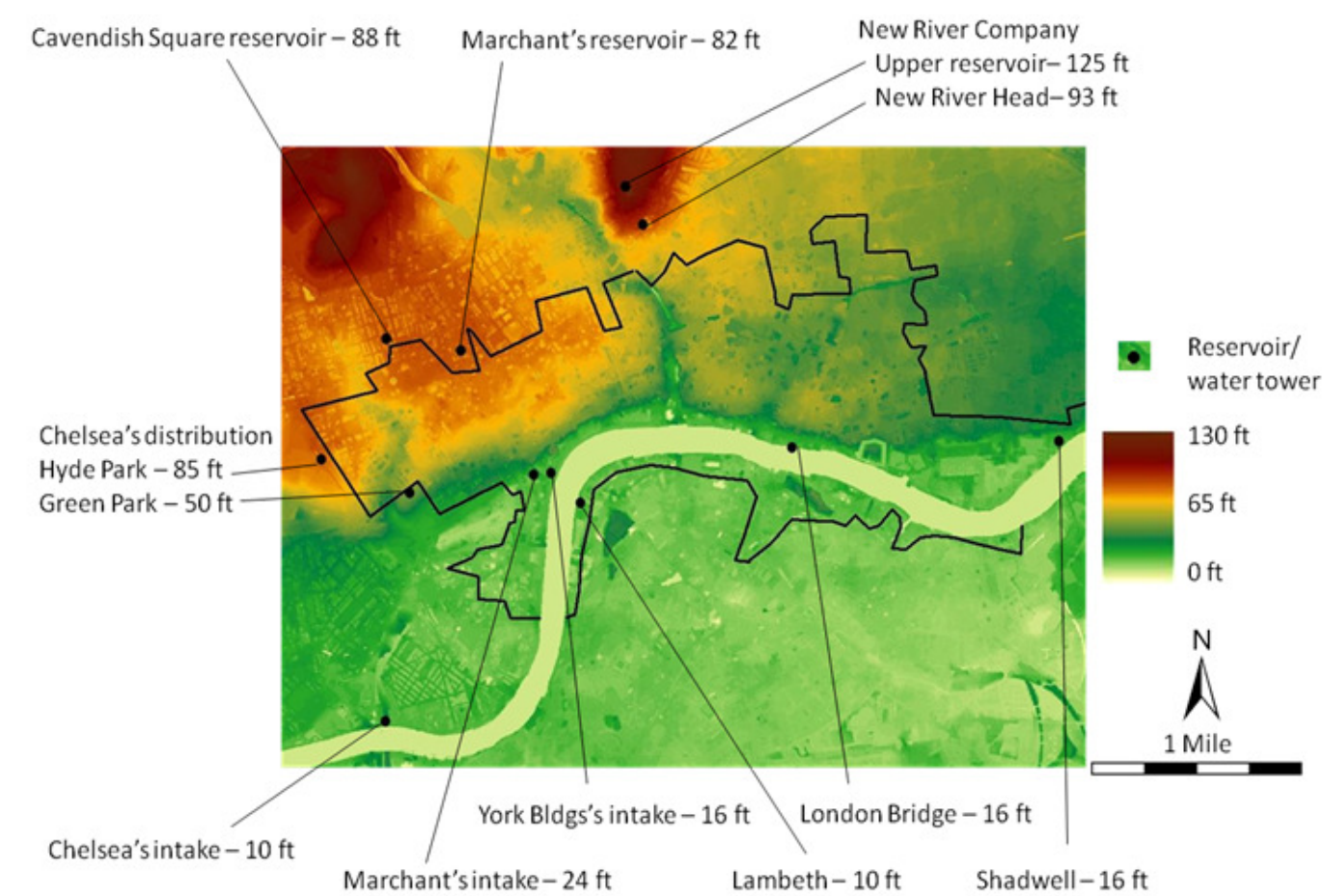
However, it did not succeed in cornering the entire West End market. A new rival, Chelsea Waterworks, emerged in the 1720s and was able to overcome both the legal as well as the technological constraints. Chelsea Waterworks ended up supplying much of Westminster and St George Hanover Square. Its promoters had obviously taken the objections to the Colne proposals into account, as they stressed in their proposal that they would not take water away from others. Their proposal, which came only six months after the defeat of the Colne proposals, emphasised they would take water from the Thames between Chelsea and the neat houses at Millbank, *without damaging the navigation of the Thames*.⁴⁹ The Parliamentary committee that investigated the matter and eventually gave the company permission also emphasised this fact repeatedly.⁵⁰

How did Chelsea Waterworks manage to supply uphill to the West End where York Buildings had failed? First of all, its high reservoir was not as high as York Buildings' (see figure 5.8). The Cavendish reservoir was at 88 ft above the Thames, while Chelsea's Hyde Park reservoir was at 85 ft and the Green Park reservoir significantly lower at 50 ft. Evidence to suggest that this was a main contributing factor can be found in the fact that, eventually, raising water to the Hyde Park reservoir, the higher of the two, caused Chelsea Waterworks problems, while raising water to the lower Green Park reservoir seems to have gone more smoothly.

⁴⁹ Journals of the House of Commons, XIX, p. 717. Emphasis added.

⁵⁰ Ibid., p. 727.

Figure 5. 8. Intake points and reservoirs in the West End.



Based on: Lindberg and Grimmond (2011).

A second possible factor lies in the fact that Chelsea Waterworks had more capital, and wealthier investors, which allowed the company to run at a loss for a few decades. Indeed, it was not until the 1750s that the company could return a regular dividend.⁵¹ There is also a third possible factor, which is the advantage of water over horse and steam technology. As mentioned previously, Chelsea Waterworks relied partly on water power (it also had a horse engine), which was cheaper than either a horse-driven or steam engine. Marchant's Waterworks, which raised water using waterwheels in the Hartshorne Lane sewer, seemed to have been able to reach a similar height as York Buildings Waterworks while solely relying on water power: the 1746 Rocque map shows a reservoir labelled 'Marchant's Waterworks' next to the Cavendish Square reservoir. Unfortunately, not much is known about this company, but the reservoir at this location indicates that, more than ten years after York Buildings had had to give up this part of the market, Marchant's was able to supply there using water power. At some point after the surveying of the Rocque map both these reservoirs were built over as new houses were developed, and the area's water shortage continued in the second half of the century.

As the West End continued to expand in the 1760s, and the distance and elevation of the customers from the existing waterworks grew accordingly, renewed efforts to bring water from the Colne emerged. In 1764, the instigator of these plans, W. Efford, published a pamphlet entitled '*A Scheme For the Better Supplying this Metropolis With Sweet and Wholesome Water from the River Coln*', in which the reasons for this new company were set out for the consideration of Parliament and the inhabitants of the West End. The main factors Efford put forward included "the apparent Want of Water at the West End of the

⁵¹ LMA/ACC/2558/CH/1/605 Chelsea Waterworks, dividend book, 1737-1760.

Town (...); the Increase of New Buildings” and the inability of the New River Company, Chelsea Waterworks, and York Buildings Waterworks “to supply the Town adequate to the Demand”.⁵² Part of this inability Efford blamed on the distance of the existing waterworks from this area. He especially singled out the New River Company, and wrote that even “if they could supply the Inhabitants with enough for necessary Uses (tho’ tis known they cannot) yet in Cases of Fires by Night their Water is generally an Hour and an Half, or two Hours before it can arrive at the Place wanted.”⁵³ These events took place during a wetter period and the capital had not suffered from droughts for years, but still an insufficient water supply was most acutely felt in times of need such as, in this case, fire. As a result, some of the main supporters of the Colne plans at this time were the fire insurance companies, which stood to pay out more damages for insured houses the longer a fire raged before being extinguished.⁵⁴

Other people who petitioned Parliament in favour of a new Colne company included inhabitants of Marylebone and the Cavendish Square area north of Oxford Street, who advocated the plan for “all the Inhabitants of that Part of the Town, who, by their Distance from the Reservoirs from which they are at present supplied, are exploited to very great Inconveniences”.⁵⁵ These people, who had previously been supplied from York Buildings and Marchant’s Waterworks’ upper reservoirs, had felt the loss the most. The Colne proposals included a distribution reservoir in Marylebone, which would be much nearer to this area than the reservoirs of either Chelsea Waterworks or the New River Company, and as a result, they supported the venture.

⁵² Efford, W., *A Scheme For the Better Supplying this Metropolis With Sweet and Wholesome Water from the River Coln* (London, 1764), p. 3.

⁵³ *Ibid.*, p. 9.

⁵⁴ Journals of the House of Commons, XIX, pp. 580, 586.

⁵⁵ Journals of the House of Commons, XXX, p. 692.

Evidence that there was a real need for water in the West End at this time, and not just petitions by people who might have had an interest in the company, can be found in the opinion of civil engineer Thomas Yeoman. His open letter was published in the *London Evening Post* on 22 November 1765, in which he praised the existing waterworks, but claimed that “by the vast increase of buildings within the liberties of Westminster, and other parts of this great metropolis, there is still a want of further supplies.”⁵⁶ As an alternative to the “several methods [that] have been proposed to obtain this desirable end” — most probably the Colne plans — he suggested the option of instead increasing the water supply in the New River by redirecting part of the river Lea.⁵⁷ Rather than displaying a partiality on the New River Company’s side by this proposal, it is more likely that he was actually concerned with improving water supply: in later years Yeoman worked for the Colne company by surveying the route of its intended canal, and answering the public’s questions on behalf of the company.⁵⁸ The demand for more water in the north-western end of town therefore was likely to be a real concern shared by more Londoners, rather than invented by those who were mainly motivated by setting up the new company.

However, as its proposal progressed through Parliament in 1766 and 1767 the same issues that had been raised in the early 1720s surfaced again.⁵⁹ The opposition from the millers and riverside communities was again too strong for the Colne proposers to overcome, and in March 1767 it was announced that they had to postpone their application for an Act of Parliament to the next session in order to find a way around all objections.⁶⁰ In

⁵⁶ Yeoman, T., letter in the *London Evening Post*, 22 Nov. 1765.

⁵⁷ Ibid.

⁵⁸ Reported in the *Gazetteer and New Daily Advertiser*, 10 Feb 1767.

⁵⁹ E.g. Journals of the House of Commons, XXX, pp. 651.

⁶⁰ *London Evening Post*, 26 March 1767, *Gazetteer and New Daily Advertiser*, 30 March 1767.

practice, this meant the end of the scheme, although rumours of attempts to start a new water company from the Colne were still circulating as late as 1789.⁶¹

The West End, as a result of its affluent inhabitants, its distance from the water companies' intake points, and the failure of local springs, had three times during the century been the focus of new companies trying to supply the area with water. While the Colne proposals had failed on two occasions, this had mainly been the result of factors outside of London: the objections were generated around the area where the water would be taken. The only proposal that had been successful was that of Chelsea Waterworks. As explored in the following section, this company soon ran into the same issue that had plagued York Buildings Waterworks in its efforts to supply this area: it had to raise its water.

5.4. Raising water: technological solutions and improvement.

In order to supply their customers at higher elevations in the West End, Chelsea Waterworks first had to raise its water from the level of the canals, which was equivalent to high water level in the Thames, to its reservoirs in the royal parks. It did this by waterwheels and a horse engine situated near the canals. As figure 5.8 has shown, the Hyde Park reservoir was about 85 ft above the Thames. Many of their customers in the West End lived even higher, so at the Hyde Park reservoir there was an additional horse-driven engine that raised the water into a cistern, which produced sufficient water pressure in the pipes to supply these houses. However, in 1735 it emerged that not enough water was being

⁶¹ LMA/ACC/2558/NR/1/3 New River Company, minutes, 9 April 1789.

pumped to the reservoir in Hyde Park to supply these higher lying services adequately.⁶² Evidently, the main concern was the horse engine that raised the water from the canals as the company began experimenting with several new designs for this engine. While most of those designs were focused on the need to raise more water, cost and efficiency were factors as well, with some of the engine proposals designed to work fewer hours or with fewer horses.⁶³

In order to save water while the engineers sorted out the supply, as a temporary solution Chelsea's directors instructed collectors to be stricter on those who wasted water in these years.⁶⁴ By 1739, however, the company's customers in Westminster were suffering from such a poor supply that they threatened to appeal to Parliament about this matter. Chelsea Waterworks' response to the threat was to consider a new horse engine again.⁶⁵ Just as York Buildings Waterworks previously, the company seems to have extended itself too high and far for the existing technology to raise an adequate amount of water.

Already suffering from these circumstances, a dry spell that hit England between 1740 and 1744 accentuated Chelsea's problems.⁶⁶ In October 1741, Mr Churchill, the company's collector of water-rents in the Westminster area, reported to a general meeting that for the past six months, during the summer of 1741, no part of his collection area had had water more than once a week, while customers were still charged the normal price. It also appeared that many tenants had complained to their landlords and were threatening to leave their houses, which propelled the owners to group together in order to seek redress in

⁶² LMA/ACC/2558/CH/1/6 Chelsea Waterworks, minutes, 31 March 1735.

⁶³ LMA/ACC/2558/CH/1/7 Chelsea Waterworks, minutes, 19 March and 16 July 1736.

⁶⁴ E.g. LMA/ACC/2558/CH/1/6 Chelsea Waterworks, minutes, 28 Aug. 1735.

⁶⁵ LMA/ACC/2558/CH/1/9 Chelsea Waterworks, minutes, 5 Dec. 1739.

⁶⁶ Brazell, *London Weather*, pp. 150, 160.

Parliament.⁶⁷ The company's directors were at a loss, and its engineers claimed that there was nothing they could do, unless there would be more rain. As they could not fix these environmental constraints, they turned their eye to their water-raising technology. It was the engineers' opinion that they had exhausted the capabilities of horse engines, thus the option of a 'fire engine', meaning an atmospheric Newcomen style steam engine, was suggested.⁶⁸

It had been a decade since the last York Buildings' steam engine had been in operation, and few people in the company knew how these engines worked and how much the solution would cost. The directors therefore ordered that this option should be investigated by sending a delegation to Bristol to look at various steam engines that were employed in local mines.⁶⁹ As in the case of York Buildings Waterworks, it is likely that the personal knowledge and business interests of the company's directors played a role in this decision. The decision to go to Bristol is an indication of this, as John LaRoche, who was the company's deputy governor at the time, owned lands and had investments in the West Country.⁷⁰ The delegation returned with a positive report, and later the same year it was decided to purchase a steam engine for "the Preservation of the Company's rents".⁷¹ Once again, while there was a structural component of an ever expanding customer base, technological innovation happened at time of water shortage and thus stress on the company.

⁶⁷ LMA/ACC/2558/CH/1/9 Chelsea Waterworks, minutes, 8 Oct. 1741.

⁶⁸ Ibid.

⁶⁹ Ibid., 29 Oct. 1741.

⁷⁰ These were mentioned in Peter Calmel's will. Calmel was the company's governor later in the century, and was involved in other ventures with LaRoche's nephew James. There was also a LaRoche merchant in Bristol, which was probably a relation. LMA/ACC/2558/CH/1/626A Chelsea Waterworks, register of wills, 1731-1765.

⁷¹ LMA/ACC/2558/CH/1/9 Chelsea Waterworks, minutes, 17 Dec. 1741.

Building and installing the steam engine took some time and did not rectify the problems immediately, and complaints about the poor supply continued. As the company needed the money to invest in its engine, the directors did not reduce the price charged for water, despite customer requests to do so. The insufficiency of supply, as well as customers' complaints, evidently continued during the next few years, since in April 1742 Mr Churchill resigned as a collector stating that he no longer wished to deal with people complaining they still had to pay even though they received no water.⁷² By June 1743 Chelsea inhabitant Alexander Small complained that there had been no water for ten weeks and in the previous two years there had rarely been water more than once in every three weeks.⁷³ The number of complaints reduced considerably soon after the steam engine started working in late 1743.

Investing in this new technology had been the answer to the long-standing problem of overcoming the difference in elevation between the points of intake and consumption, while the catalyst to get the process moving was a drought. Chelsea Waterworks' decision to invest in a steam engine as a strategy to raise more water and thus reach more people turned out to be a successful one. At several occasions later in the century, in 1760 and again in 1773, its directors considered building additional steam engines. Both times this was motivated by discussions about the expanding West End market north of Tyburn Road.⁷⁴

However, as York Buildings had experienced as well, having a steam engine did not come cheap. The main costs, after the initial investment, were the price of coal and the higher

⁷² LMA/ACC/2558/CH/1/9 Chelsea Waterworks, minutes, 6 April 1742.

⁷³ LMA/ACC/2558/CH/1/10 Chelsea Waterworks, minutes, 10 June 1743.

⁷⁴ LMA/ACC/2558/CH/1/12 Chelsea Waterworks, minutes, 22 Feb. 1760; LMA/ACC/2558/CH/1/13 Chelsea Waterworks, minutes, 8 July 1773.

labour costs of skilled engine workers. This first cost factor was to become the subject of many improvements being made by engineers in order to make the engine more efficient and use less coal. In 1747, after only a few years' experience with their purchased engine, Chelsea Waterworks' engineers managed to build a second one, which could raise the same water with the same or less coal than the old one.⁷⁵

More small improvements were made over the century, but the main technological improvement was the condensing steam engine made by James Watt, which he and Matthew Boulton patented in 1775.⁷⁶ The design reduced the consumption of steam, and consequently that of coal, while maintaining power. Because of its efficiency the Boulton-Watt engine quickly became popular, especially in regions where the coal price was high, which included London.⁷⁷ Chelsea Waterworks was one of the first to adopt these improvements and instructed Boulton and Watt to construct an engine in October 1776, which is depicted at work in figure 5.9.⁷⁸

Steam technology proved useful for the companies, as their technological demands were very similar to those in mining, the original purpose for which the engines had been designed, but London's position at a distance from cheap coal supplies meant that they only became a good investment once the designs had become more efficient. York Buildings Waterworks had been at a disadvantage by making the investment too early. However, topography and location of the company meant that the need to raise water remained the

⁷⁵ LMA/ACC/2558/CH/1/10 Chelsea Waterworks, minutes, 19 Aug. 1747.

⁷⁶ Briggs, A., *The power of steam* (London, Michael Joseph, 1982), pp. 52-4.

⁷⁷ Hills, R.L., *James Watt, volume 2: the years of toil, 1775-1785* (Ashbourne, Landmark Publishing, 2005), p. 38.

⁷⁸ LMA/ACC/2558/CH/1/13 Chelsea Waterworks, minutes, 3 Oct. 1776.

key constraint on its business and eventually it invested in a (newer) steam engine, which was the one shown blowing out steam in figure 5.1.⁷⁹

Figure 5. 9. Chelsea Waterworks, 1782.



Engraving by Jefferyes Hamett O’Neale. Source: © Trustees of the British Museum.

In 1757 the secretary of York Building’s Waterworks approached Chelsea Waterworks to apply together to Parliament for duty relief on coals for their steam engine. The other company that joined them at this time was Shadwell Waterworks, which suggests that only these companies had a Newcomen engine.⁸⁰ Once the Boulton-Watt improvements had been made, more companies made the move to steam technology. The New River Company, Shadwell, and London Bridge Waterworks all installed Boulton-Watt engines in

⁷⁹ Dickinson, *Water supply*, p. 64.

⁸⁰ LMA/ACC/2558/CH/1/11 Chelsea Waterworks, minutes, 28 Jan. 1757.

the 1780s, and Lambeth Waterworks decided in 1800 they wanted their engine to work on Watt's principle.⁸¹

The New River Company had been able to avoid experimenting with early steam technology as it could make use of gravity for much of its distribution. The only place where it required the water to be raised was from the New River Head to the upper reservoir that had been constructed in 1708 to supply the West End, and was 33 feet higher. Initially a windmill had been used for this, but soon it was replaced with horsepower.⁸² As demand for New River water in the West End increased, the company employed John Smeaton to advise about water-raising technologies, and in 1768 it installed a steam engine.⁸³ This engine, built by Smeaton, turned out to have very high running costs and Robert Mylne, the New River Company's engineer, had a waterwheel constructed sometime in the 1770s, which probably worked alongside the steam engine to raise water to the upper reservoir.⁸⁴

Raising more water to the high pond allowed the company to increase its water supply to the West End. In 1767, before the engine was operative, the New River Company had four mains that fed into the West End: the Soho main, which was on for 21 hours a week, the Grosvenor main, on for 24 hours a week, the Oxford main, which supplied 15 hours a week, and the Portland main, on for six hours a week.⁸⁵ Once the engine was operative, it was able to almost double these hours, going from a total of 66 hours to 117 hours, and by 1773 to

⁸¹ Boulton left Chelsea Waterworks with an example of a payment plan for the patent, based on his payment plan with Shadwell Waterworks. LMA/ACC/2558/CH/1/13 Chelsea Waterworks, minutes, 1 June 1780; LMA/ACC/2558/LB/1/3 London Bridge Waterworks, minutes, 26 March and 21 May 1784; LMA/ACC/2558/NR/1/2 New River Company, minutes, 24 Feb. 1785; LMA/ACC/2558/LA/1/2 Lambeth Waterworks, minutes, 27 Jan. 1800.

⁸² Dickinson, *Water supply*, p. 38.

⁸³ Ward, *New River*, p. 152.

⁸⁴ *Ibid.*, p. 154.

⁸⁵ *Select committee*, PP 1821 (706), p. 3.

150 hours.⁸⁶ The increased water supply allowed the company to continually extend its services in the West End, and in 1775 it constructed an additional main to Marylebone.⁸⁷ Over the next few years a large number of new customers applied to be connected to this main.⁸⁸ By 1780 the company supplied for almost 230 hours a week to the West End, which mainly reflected an increase of customers rather than an increase in hours per customer.⁸⁹

London Bridge Waterworks also switched to steam technology at a later date. It had dealt with its increasing customer base by adding new waterwheels under more arches, and by the mid-eighteenth century it ran five waterwheels under three arches. The decision to move to steam technology in 1762 was a complex one. It was partly undertaken to overcome its dependence on the tides, and partly because as the middle arches of the bridge were joined in 1759, the flow of water had become less forceful. Around the same time the company started supplying south of London Bridge, eventually building an engine there as well. This was possibly done as the directors realised that the company would not be able to compete against the New River Company in the City. London Bridge Waterworks had to give up supplying Grubb Street and Moor Lane in the northern parts of the City in 1786, as it was no longer profitable to supply these customers uphill.⁹⁰ In March 1794 its bi-annual stock dividends had to be lowered from 30s to 20s.⁹¹ In November of that year the directors decided that there would be no possibility of increasing custom in the City due to the superior power of the New River Company, as well as the conversion of many dwelling houses into warehouses, and they recommended focusing on Southwark to make their

⁸⁶ *Select committee*, PP 1821 (706), p. 3.

⁸⁷ Rudden, B., *The New River: a legal history* (Oxford, Clarendon Press, 1985), p. 99. Also LMA/ACC/2558/NR/1/1 New River Company, minutes, 24 April 1775 and 20 July 1775.

⁸⁸ LMA/ACC/2558/NR/1/1 New River Company, minutes. Decision taken at general court on 20 July 1775, many applications for connections at meetings in 1777 and 1778; *Select committee*, PP 1821 (706), p. 208.

⁸⁹ *Select committee*, PP 1821 (706), p. 3.

⁹⁰ LMA/ACC/2558/NR/1/3 New River Company, minutes, 28 Sep. 1786.

⁹¹ LMA/ACC/2558/LB/1/20 London Bridge Waterworks, dividend book, 1794.

profits.⁹² This strategy seemed to work and by April 1799 the dividends were back up to 30s.⁹³

While the introduction of steam technology had allowed the companies to satisfy their increasing customer demand, and had enabled them to cope with droughts, it had implications for the rest of the network. The wooden pipes had always been the weak part of the network and did not cope well with water pressure. They were already generally leaky under the pressure required to transport the water, but at increased pressures they could burst.⁹⁴ With each strike of the steam engine, the water was raised more forcefully than the horse and water engines had ever achieved. The first time Chelsea Waterworks' employees went to see a steam engine they realised that this would create too much pressure in the wooden pipes.⁹⁵ They were right: at the trial of the first steam engine in December 1742 the mains burst.⁹⁶ The engine therefore had to be switched to lifting less water so as not to fracture the mains, and eventually the company made iron pipes from the engine to the reservoir.⁹⁷ For this reason, steam engines were mainly used to raise the water into a higher reservoir or water-tower rather than directly supply the mains.

Neither did steam technology completely replace earlier technologies. Horse, water, and wind power still continued to play an important role and ran parallel to the steam engine, or were even introduced after the establishment of a steam engine. In 1775, after the company had been using steam power for three decades, the directors of Chelsea Waterworks considered building a windmill, like the New River Company had done, but

⁹² LMA/ACC/2558/LB/1/4 London Bridge Waterworks, minutes, 14 Nov. 1794.

⁹³ LMA/ACC/2558/LB/1/20 London Bridge Waterworks, dividend book, 1799.

⁹⁴ Stewart, *Rise of science*, p. 337.

⁹⁵ LMA/ACC/2558/CH/1/9 Chelsea Waterworks, minutes, 29 Oct. 1741.

⁹⁶ *Ibid.*, 3 Dec. 1742.

⁹⁷ LMA/ACC/2558/CH/1/9 Chelsea Waterworks, minutes, 17 Dec. 1742. Iron pipes were more expensive than wooden pipes, which is why they were only used sparingly. *Select committee*, PP 1821 (706), p. 181.

decided against it on grounds of the unreliability of the wind.⁹⁸ In 1784, however, they changed their minds and decided to install a windmill, both because it would save the expense of working the steam engine but also as it could be put to work independently of the tides, and so could take over from the waterwheels and maintain supply even during the lowest tides.⁹⁹ It was working by November 1785, and even allowed the company to expand its service.¹⁰⁰ While cost issues were likely to have played a role here, the water companies obviously found that different engines had certain advantages over steam technology as well.

The different technological choices that the companies made, or were forced to make as a result of the geography of their intakes and customers, shaped the water market significantly. Their early forays in steam technology had been disastrous for York Buildings Waterworks, while the New River Company had been able to expand without having to risk investing in water-raising engines. While geography and technology differentiated the companies and determined the areas which they were able to supply, the next task in the water supply process, distribution, posed very similar challenges to all companies. As they were only able to raise a limited amount, they had to manage their supply in a way that balanced, on one hand, the customers' demands, and on the other hand, the companies' desire to supply as many people as possible. The next section looks at how the companies dealt with this.

⁹⁸ LMA/ACC/2558/CH/1/13 Chelsea Waterworks, minutes, 2 March 1775.

⁹⁹ LMA/ACC/2558/CH/1/14 Chelsea Waterworks, minutes, 30 Dec. 1784. Even the steam engine needed some water to run.

¹⁰⁰ *Ibid.*, 3 Nov. 1785 and 26 Jan. 1786.

5.5. Managing water: distribution, pricing, and balancing demands.

Because of the expenses related to raising or transporting water to the distribution towers and reservoirs, its availability was limited. As their networks and number of customers expanded, the companies had to save water in some places of the network so it could be spread out to reach as many people as possible. Different parts of the network had different requirements. For example, supplying uphill or to the end of a main required as much pressure as possible to force the water into the furthest service pipes. Customers had different requirements as well: there were variations in the amounts required, as well as areas that had seasonal fluctuations in demand.

There were several ways in which the companies could regulate their water. Firstly, they could adjust their schedule of supply; secondly, they could transfer customers onto other services; and lastly, they could compel the consumer either to use less water, or pay more for the water they received. The easiest way to save water was to cut down the hours of supply. In 1729 Chelsea Waterworks decided to switch on its services to certain areas three hours a day for six days a week, rather than seven hours a day for three days a week. This provided a weekly total of 18 hours of water rather than 21, meaning that the company had three hours in which the water could be redirected into another service.¹⁰¹ There were no complaints about this change on record, and it seems to have worked well for the company, as when it was under pressure to regulate its water better as a result of drought in the 1730s, the directors repeated the practice. Chelsea Waterworks reduced the supply to these areas to only four days a week, but added an extra hour each day to make it four hours. This

¹⁰¹ LMA/ACC/2558/CH/1/3 Chelsea Waterworks, minutes, 12 June 1729.

meant it was supplying only 16 hours per week on that service, and saved another two hours, which were used to supply customers on another main who had been complaining about a poor supply.¹⁰² By changing the frequency of supply, the company was thus able to spread out the available water over its expanding customer base.

Another way of saving water was to move people off the main and put them onto services. As each main fed into several services, the main was charged with water for the time allocated to all these services, and therefore people connected to a main received water more often. The companies preferred to have their customers on the service pipes rather than on the mains as it enabled them to regulate the water better and ensured the highest possible water pressure on the main itself. When a company extended its supply to a new area, however, there was often only one main to which customers had to connect. Once the network started to branch out, these people had to be moved onto services, so that they only took water during the time their own service was on, while the main was left to supply other customers. This happened in the 1780s to the New River Company's new main into Marylebone, and the company set up a special committee to move customers to new services.¹⁰³ Similarly, it moved customers on the Bloombury main to a separate service when there were complaints of deficient water pressure from Mr Stephenson's brewhouse, at the end of the main.¹⁰⁴

The last way of regulating water was being stricter on wastage. During a drought in the early 1730s Chelsea Waterworks imposed several water saving measures.¹⁰⁵ Firstly, its directors decided to cut off customers that were in arrears with their bills, and stopped

¹⁰² LMA/ACC/2558/CH/1/6 Chelsea Waterworks, minutes, 4 March 1735.

¹⁰³ LMA/ACC/2558/NR/1/2 New River Company, minutes, 27 Feb. and 8 April 1783.

¹⁰⁴ LMA/ACC/2558/NR/1/3 New River Company, minutes, 21 Jan. 1790.

¹⁰⁵ LMA/ACC/2558/CH/1/5 Chelsea Waterworks, minutes, 21 June 1733.

supplying to uninhabited houses, even if the landlord had paid for supply.¹⁰⁶ In addition, they started cutting off people in areas in which the company was having too many problems supplying, and to which the cost of supply was not covered by the income. This is what happened in 1735 to the people at the end of a main near Tyburn Road: the directors of Chelsea Waterworks judged that it would be to the detriment of the company to supply them, since it required a lot of water to reach a sufficient pressure, which could easily be supplied somewhere else.¹⁰⁷ Similarly, the company cut off an inhabitant of Vine Street, as he was the only customer taking Chelsea water while the rest of the street was with the New River Company and did not want to change.¹⁰⁸

In addition, the company's directors became stricter on customers that let other people share their water. This practice was possible as the companies did not charge for their water based on quantity, but made estimations of usage according to the size of buildings, amenities such as water closets or fountains, and any water-using trades being practiced in a house. Larger consumers, such as brewers or those who paid for the supply of their stables, often had an open cistern or well in their stable yard, from which they let other people take water. Chelsea Waterworks' directors tried to stop this practice, with the intention that either less water would be used, or that the people that took the water would apply to become paying customers themselves. In the 1730s the company ordered its collectors to give notice to stable yard owners and brewers who shared their water that they had to lock their cisterns away, or pay an extra charge for the people they allowed to

¹⁰⁶ LMA/ACC/2558/CH/1/5 Chelsea Waterworks, minutes, 21 June 1733.

¹⁰⁷ LMA/ACC/2558/CH/1/7 Chelsea Waterworks, minutes, 13 Aug. 1735.

¹⁰⁸ LMA/ACC/2558/CH/1/8 Chelsea Waterworks, minutes, 26 Oct. 1737.

use it.¹⁰⁹ As none of the companies could monitor the quantity of their supply, and water was provided during the time that the service was on, the brewer or stable yard owner could still take the same amount of water from the company. These measures were therefore unlikely to have saved water, though they would probably have resulted in more income for the company.

When managing their water, the companies also had to take into account the various demands of the users. Firstly, there were certain groups of customers that needed more water than others. Secondly, there were seasonal fluctuations in demand, as well as certain times when supply was needed. Lastly, there were concerns about the quality of supply. The larger consumers were usually those who needed water for their trade. In order to satisfy demand and not to waste water, the companies had to adjust their infrastructure in order to only supply these people with extra water. Directing extra water to these buildings could be achieved in three ways. The first option was to supply them via a larger pipe, which provided more water once the service was on. The second option was to switch on their service for a longer time. The drawback of this solution was that the other customers on that service would receive extra water as well, without having to pay the extra charge for it. The last option was to supply them directly from the mains, which were charged with water more often, and which would require only some additional pipe infrastructure.

The last option seemed to have been the preferred one. When Mr Rea, a brewer of Knightsbridge, applied for an additional day of water service from Chelsea Waterworks, the company's directors replied that this could not be done without also supplying the 20 neighbours on the same service. Supplying these domestic customers with extra water was

¹⁰⁹ LMA/ACC/2558/CH/1/6 Chelsea Waterworks, minutes, 5 Dec. 1734 and 27 Aug. 1735; LMA/ACC/2558/CH/1/7 Chelsea Waterworks, minutes, 7 March 1737.

considered to be 'a waste' by the company, and therefore Rea had to pay towards the construction of an extra pipe from the main. The company also increased his rent by £5 per year, but agreed that this would keep him supplied every time that this main was on, which was three times a week.¹¹⁰ When Mr Smith, a brewer of Tyburn Lane, used a larger pipe to increase his supply but took so much water that it disadvantaged the other customers on that service, Chelsea Waterworks made him pay for a separate pipe towards the main to remedy this, which freed up the water on that service for the other consumers.¹¹¹

There was also the issue of how supply to these larger consumers should be priced. Customers that were supplied with more water had to pay a higher price, but as the companies could not measure how much water they supplied, it was difficult to determine how much they should pay. These difficulties were encountered by Chelsea Waterworks in 1731, when it had only been in business for a few years. The company had received an application to supply a large brewery, and had tried to estimate the amount of water it needed by measuring its 'liquor back' where the water would be stored. As the directors were unsure how to determine the price, they approached the New River Company to enquire how they handled the provision of 'large brewhouses'.¹¹² The response indicated that breweries supplied by the New River Company were charged based on the number of barrels of beer they brewed. For example, a brewery that brewed 30,000 barrels would pay £30.¹¹³ As their annual output could be measured, this was what the companies based their prices on. Lambeth Waterworks, on one occasion, sent an employee to the excise office to

¹¹⁰ LMA/ACC/2558/CH/1/11 Chelsea Waterworks, minutes, 31 May 1754.

¹¹¹ LMA/ACC/2558/CH/1/9 Chelsea Waterworks, minutes, 17 Oct. 1739.

¹¹² LMA/ACC/2558/CH/1/5 Chelsea Waterworks, minutes, 10 Nov. 1731.

¹¹³ Ibid.

check the amount of beer brewed by a new customer, so the company could charge him accordingly.¹¹⁴

Another way of measuring water use was charging sugarbakers based on the amount of pans they used. However, there were many other industries for which there was no easy way to measure the approximate use of water, and contracts often seem to have been negotiated on an ad hoc basis. The collectors of the New River Company were instructed to look for distillers, soap boilers, taverns, fishmongers, and dyers in their district, as these were high water users.¹¹⁵ Chelsea Waterworks identified breweries, washerwomen, and public houses as using a lot of water.¹¹⁶ Dye-houses, tanners, and sugarhouses as well as a parchment maker were among other industries that had separate contracts and thus bought a lot of water.¹¹⁷

Apart from customers needing more water, the companies also had to manage seasonal fluctuations in demand. Less water was taken up in summer, due to the fact that there were fewer people in town. The reason for this was that the wealthy, who were more likely to have water supplied to their houses, would spend time in the countryside. Grand Junction Waterworks, which mainly supplied the West End, estimated in 1821 that 300 to 400 of its customers were out of town during the summer months.¹¹⁸ This was enough to influence the companies' water management: when Chelsea Waterworks had to release the water from one of its reservoirs in order to make repairs its directors decided to postpone the

¹¹⁴ LMA/ACC/2558/LA/1/2 Lambeth Waterworks, minutes, 1 July 1794.

¹¹⁵ LMA/ACC/2558/NR/1/1 New River Company, minutes, 25 June 1772.

¹¹⁶ LMA/ACC/2558/CH/1/3 Chelsea Waterworks, minutes, 30 May 1728.

¹¹⁷ LMA/ACC/2558/CH/1/15 Chelsea Waterworks, minutes, 1 Aug. 1793; LMA/ACC/2558/LB/1/1 London Bridge Waterworks, minutes 27 June 1777; LMA/ACC/2558/LB/1/3 London Bridge Waterworks, minutes, 30 May 1783; LMA/ACC/2558/LB/1/4 London Bridge Waterworks, minutes, 24 April 1789.

¹¹⁸ This was one of the new companies of the 1800s. *Select committee*, PP 1821 (706), pp. 26, 34.

works until summer, when less water would be required.¹¹⁹ In spring, on the other hand, demand rose as the wealthy would spend more time in the capital. For this reason, the New River Company laid on an additional hour three times a week on the Portland main in March 1776.¹²⁰ Again in 1796, this company supplied extra water in several West End mains on Sundays from February until June — a measure which was repeated the following year.¹²¹

The timing of the supply also mattered to consumers: in 1732 some Chelsea customers complained that the water was delivered too late in the day for them.¹²² Timing was an even more pressing issue for industrial customers, whose trade depended on the water companies' hours of supply. Mr Rea, the Knightsbridge brewer, was so unhappy with the irregularity of Chelsea Waterworks' supply, which meant that he could not work fixed hours, that he threatened to quit his custom.¹²³ Another set of Chelsea customers complained in 1743 about the irregularity of their supply, which the company thought of as a reasonable complaint, and in response it committed to supply on certain days. However, as these customers were supplied directly from the canals, their supply depended on the tide, and a more regular supply could only be achieved if the tide permitted.¹²⁴

Judging from this company's response, the timing of the supply was judged as a reasonable cause for complaint that should be fixed. In response to other complaints about poor timings, Chelsea Waterworks briefly considered putting the tenants in control of the turncocks so they could determine their own water supply, but eventually decided against

¹¹⁹ LMA/ACC/2558/CH/1/4 Chelsea Waterworks, minutes, 10 March 1731.

¹²⁰ LMA/ACC/2558/NR/1/1 New River Company, minutes, 7 March 1776.

¹²¹ LMA/ACC/2558/NR/1/4 New River Company, minutes, 11 Feb. 1796 and 26 Jan. 1797.

¹²² LMA/ACC/2558/CH/1/5 Chelsea Waterworks, minutes, 7 Jan. 1732.

¹²³ *Ibid.*, 10 Nov. 1731.

¹²⁴ LMA/ACC/2558/CH/1/10 Chelsea Waterworks, minutes, 10 June 1743.

it.¹²⁵ In order to manage their water supply the companies needed to keep control over how many people were on a service. When in 1735 a group of people illegally managed to get hold of the turncock keys in order to supply themselves whenever they wished, this occasioned an investigation and the directors looked into ways of punishing those who were liable. This group included brewers and innholders, people who depended on water for their trade.¹²⁶ Regularity and timing of service was taken seriously and was something on which water companies competed: in 1757 Chelsea Waterworks lost customers to the York Buildings Company as this company could provide Charles Street more often.¹²⁷ Chelsea's customers around Sloan Street complained about only receiving water twice a week, and appealed to the New River Company, which built a main that would supply them more often.¹²⁸

The final cause for complaint was the quality of supply. As customers had different uses for the water, some cared more about this than others. For example, brewers were greatly concerned about the quality of their water as it was of considerable importance for the quality of the beer they brewed. Generally, water from wells and springs was better than that from the Thames, and most brewers preferred water from wells or took New River water, although Thrale of the Southwark Anchor Brewery used river water.¹²⁹ Hampstead spring water was considered very wholesome and well suited for brewing.¹³⁰ Chelsea Waterworks' water, which came from the Thames, was only used to brew dark beers. Some

¹²⁵ LMA/ACC/2558/CH/1/11 Chelsea Waterworks, minutes, 19 May 1757.

¹²⁶ LMA/ACC/2558/CH/1/7 Chelsea Waterworks, minutes, 13 and 27 Aug. 1735.

¹²⁷ LMA/ACC/2558/CH/1/11 Chelsea Waterworks, minutes, 3 May 1757.

¹²⁸ LMA/ACC/2558/CH/1/14 Chelsea Waterworks, minutes, 29 Dec. 1785.

¹²⁹ Mathias, P., *The brewing industry in England, 1700-1830* (Cambridge, Cambridge University Press, 1959), pp. 16, 44.

¹³⁰ *Post Man and the Historical Account*, 10 Jan. 1716.

of Chelsea's customers who also brewed pale beers explicitly stated they used water from a well for this, rather than the company's water.¹³¹

There is not much evidence about whether company water was habitually drunk or not, but there were indications that occasionally it was. Water from Hampstead springs was brought fresh every morning to several places in town, such as coffee houses at Temple Bar, Charing Cross, and the Stock Exchange, as well as a distillery at Holborn Bars, which was advertised.¹³² In a discussion between Alexander Geekie and John Locke, the latter of whom was an advocate of water drinking, Geekie thanked him for his advice on water drinking and asked him where he received his water from. He added: "mine is New River water. How is it to be settled pray Sir without a stone strainer. Will chalk or oat meal doe?"¹³³ This indicates that the water needed to be filtered before it could safely be drunk. Practices as these, as well as some of the words people used to describe the quality of water, such as 'thick' and 'corrupted', imply that there were solid elements in the water.

The companies took complaints about the quality of their water seriously, and, if correct, tried to remedy the matter. One of these remedies was filtering the water. When Chelsea Waterworks' customers complained in 1734 that the water kept in the new reservoir in Hyde Park was green and foul, the company spread a haircloth over the entrance of the pipes in order to filter out impurities.¹³⁴ This was not effective for long, as in 1748 customers again complained about the "Foulness, Colour, Taste & Smell of the Water" originating from

¹³¹ E.g. Coussmaker and Co. LMA/ACC/2558/CH/1/11 Chelsea Waterworks, minutes, 9 Dec. 1755.

¹³² *Daily Courant*, 4 May 1717.

¹³³ Geekie, A., 'Alexander Geekie to John Locke: Wednesday, 23 December 1702 — [letter]', in R. McNamee et al, ed., *Electronic Enlightenment* (Oxford, University of Oxford Press), online edn.: [http://0-www.e-enlightenment.com.catalogue.ulrls.lon.ac.uk/item/lockjoOU0070724_1key001cor/, accessed 30 Nov. 2012].

¹³⁴ LMA/ACC/2558/CH/1/6 Chelsea Waterworks, minutes, 15 Aug. 1734.

the same reservoir, which was then ordered to be cleaned.¹³⁵ As a result of persistent complaints, in 1775 the company decided to clean the Green Park reservoir, as the directors believed the foulness of the water was caused by weeds growing in the water.¹³⁶

The fact that the reservoirs were often used for other activities did not help to improve quality. Deer had been drinking from Chelsea's ponds, which caused the company to fence these off.¹³⁷ Similarly, in 1783, 42 inhabitants of Battle Bridge petitioned the New River Company that the water they received from the high pond was "thick and unclean" as people were bathing in there, and they could not use it without prejudicing their health. Following this petition, the New River Company fenced off that pond, which was in the middle of a field.¹³⁸ As the water was sitting in companies' reservoirs and later in customers' cisterns, it festered in higher temperatures, and so there was a seasonality to quality complaints: most of them were made in summer.¹³⁹ Flowing water was therefore preferred over water that had been kept in a reservoir: recipients of New River water from the high pond described the water as "bad and putrid and corrupted" in July 1785, and demanded "wholesome running water" rather than water that had been allowed to sit in the reservoir.¹⁴⁰

¹³⁵ LMA/ACC/2558/CH/1/10 Chelsea Waterworks, minutes, 19 Aug. 1748.

¹³⁶ LMA/ACC/2558/CH/1/13 Chelsea Waterworks, minutes, 18 May and 1 June 1775.

¹³⁷ LMA/ACC/2558/CH/1/1 Chelsea Waterworks, minutes, 2 June 1726.

¹³⁸ LMA/ACC/2558/NR/1/2 New River Company, minutes, 17 and 24 July 1783.

¹³⁹ Over the century, 4 recorded complaints were made in August, 3 in July, 2 in May and one each in March and June. Only 1 complaint was made in January, and 1 in November.

¹⁴⁰ LMA/ACC/2558/NR/1/2 New River Company, minutes, 14 July 1785.

5.6. Extending the network.

A final issue that constrained the expansion of a company was the cost of its infrastructure. The wooden pipes were expensive — 5s 2d per yard in 1810 — and the water companies had to weigh up the cost of extending the network into a new street against the profit that it would generate.¹⁴¹ A water company needed to be sure that it would have a minimum number of new customers that would make the investment in pipes worthwhile. For example, Lambeth Waterworks would only extend its network to a street near Blackfriars if the company could be assured that there would be at least 12 to 20 houses there taking up its water.¹⁴² Customers that asked for the water network to be extended to their neighbourhood were also aware of the expenses a company incurred when it had to lay new pipes. In 1771, a petition for supply by a group of inhabitants of Cross Street, Islington, to the directors of the New River Company emphasised that there were enough of them who would “be glad to become your Tennants” and ensured the company that “we shall make it worth your Expences, as there is many new houses fitting up for Tennants”.¹⁴³

When builders or estate developers applied to have their new buildings supplied with water, the water companies often asked them to contribute to the costs of laying the pipes, as this new infrastructure would be of benefit to both. Having their new houses supplied with water was an advantage for the owner, who could then use it to advertise the premises.¹⁴⁴ By the end of the century there were areas in which water supply was expected to be available in a new house, and this placed the water companies in a strong position to

¹⁴¹ *Select committee*, PP 1821 (706), p. 49.

¹⁴² LMA/ACC/2558/LA/1/1 Lambeth Waterworks, minutes, 16 May 1786.

¹⁴³ LMA/ACC/2558/NR/13/207/3. Unfortunately there is no record whether they were successful or not.

¹⁴⁴ An example of a house advertised as water-rent included: *Daily Courant*, 6 Nov. 1718.

negotiate a contribution from the developers.¹⁴⁵ For example, when the proprietor of six houses near Old Palace Yard, Westminster, asked Chelsea Waterworks to supply these from their main in College Street, the company's directors decided that this would mainly be for the benefit of the owner, and not for the company. Consequently, the proprietor had to pay for the construction of a new service pipe from College Street to Old Palace Yard.¹⁴⁶

By contrast, when the earning potential of a new area was large enough, the companies were more willing to make the investment. When the developer of houses in Mount Street and adjacent streets applied for Chelsea water, the company considered that this would benefit the company because the potential water-rent was more than the cost of the pipes, and accordingly the applicant was not asked to make a contribution. Still, the company tried to re-use old pipes where possible in order to lower the costs.¹⁴⁷ In 1760, Chelsea Waterworks decided to extend its infrastructure north through the West End on its own initiative, as its directors had realised that there were a lot of streets and buildings planned around Tyburn Road.¹⁴⁸

If the earning potential of an area was high enough, developers were able to play multiple companies against each other. Mr Mallors, who was building houses in Great George Street, initially chose to take York Buildings water over Chelsea water as the former company had offered to contribute more towards the laying of the pipes. However, as Chelsea's directors had estimated that this street would have a £100 per annum rent potential they sent a representative who was known to have some influence over Mallors to

¹⁴⁵ Landlords complained that no lodger would stay with them without a water supply. LMA/ACC/2558/LA/1/1 Lambeth Waterworks, minutes, 23 Nov. 1790.

¹⁴⁶ LMA/ACC/2558/CH/1/10 Chelsea Waterworks, minutes, 18 Nov. 1743.

¹⁴⁷ LMA/ACC/2558/CH/1/9 Chelsea Waterworks, minutes, 23 July 1741.

¹⁴⁸ LMA/ACC/2558/CH/1/12 Chelsea Waterworks, minutes, 22 Feb. 1760.

negotiate.¹⁴⁹ This seemed to have been a successful move: in 1761 Mr Mallors' houses in Great George Street were mentioned as being supplied with Chelsea water, and he was negotiating with the company about supplying the rest of the street.¹⁵⁰ An initial investment, therefore, could pay off as more tenants were expected as the area continued to expand.

The main factors that companies took into consideration when deciding whether to invest in pipes included the distance from other available water sources as well as the likely affluence of the inhabitants. Both these issues were considered by Lambeth Waterworks when it started up business in 1782. At an initial meeting, the men who were to become the company's directors weighed up the potential for commercial supply in south London by compiling two lists of streets. One contained the streets that were in want of water and included inhabitants that would be able to afford paying for it. The other one contained places that were so far away from the company that the inhabitants' estimated contribution towards the cost of the infrastructure was so high that the company doubted they would agree to it. It also included streets that were so close to the river that people were likely to prefer to fetch their own supply.¹⁵¹

This last issue played an important role in the companies' decisions to extend the network or not: when alternative sources were available there was less reason to take up a commercial supply. When in 1794 Chelsea Waterworks looked into supplying the New Town near Queens Elm Turnpike (present Fulham), it was found that most people were supplied with rain and pumpwater, and in dry seasons they used the river. The directors calculated that only one in ten inhabitants would be willing to pay for Chelsea water, and this would

¹⁴⁹ LMA/ACC/2558/CH/1/11 Chelsea Waterworks, minutes, 3 Dec. 1757.

¹⁵⁰ LMA/ACC/2558/CH/1/12 Chelsea Waterworks, minutes, 3 June 1761.

¹⁵¹ LMA/ACC/2558/LA/1/1 Lambeth Waterworks, minutes, 25 April 1785.

not generate enough profit to make the expense of constructing the infrastructure worthwhile.¹⁵²

5.7. Conclusion.

On a basic infrastructural level the water supply companies were very similar: they all used the same sort of pipes, had the same system of intermittent supply, and all had to manage their customer demands in terms of quantity, frequency, and quality. On a larger scale, however, there were significant differences between the companies. The trajectories they took were dependent on the complex interaction of several factors, including their spatial configurations, technological choices, and the motivations of specific individuals. The elevation of a company's water intake point vis-a-vis its customer base determined the power the company had to generate in order to maintain sufficient pressure in the pipes to supply their customers. The way this power was generated depended on the options available to a company, but also on the decisions taken by its directors.

Technological choices, and the timing of investment in innovations, proved vital for the companies. Those that supplied a customer base significantly higher than their intake points were the first to investigate new technologies, while others had been able to leave it until innovation made the investment in steam technology more cost-effective. But geographical constraint was not the only factor: an insufficient water supply became particularly evident in times of shortage, and periodic droughts in the early eighteenth century pushed the

¹⁵² LMA/ACC/2558/CH/1/15 Chelsea Waterworks, minutes, 25 Sep. 1794.

companies, and others, to increase water supply in the West End, either by establishing new companies or through enlarging storage facilities. Similarly, climatic events proved the catalyst for Chelsea Waterworks to invest in steam technology in order to deal with its expanding customer base.

Technological choices, and the spatial configurations they were based on, played an important part in the shaping of London's water market. The New River Company, due to its favourable geographic location, was able to expand without having to risk investing in a water-raising engine, and this particularly advantageous position allowed them to become the city's largest supplier. Other companies, such as York Buildings and London Bridge Waterworks, were forced to use the Thames and could not compete with the New River Company, as they would have to supply customers uphill. These companies had to find solutions to extend their networks, either by expanding across the river, as London Bridge Waterworks did, or by competing against their rivals.

But even the companies that could expand towards London's growing outskirts, such as Chelsea and Lambeth Waterworks, and the New River Company, had to make decisions whether to extend their network or not. The infrastructure of each of the companies, including their engines and pipes, was expensive, and directors had to decide if it was worthwhile to invest in an area, and whether the expenditure for the pipes was viable. The fact that the companies had to lay out physical networks before they could earn money through supply meant that they were careful about where to invest their limited resources.

Chapter 6. The water market: expansion, structure, and debate.

The supply of urban utilities, such as water or gas, require large and costly grid-based systems of delivery.¹ In the case of the water companies that supplied eighteenth-century London, these costs were substantial: the construction and maintenance of a system of reservoirs, pipes, and engines required raising a considerable capital to cover the initial outlays of their infrastructure. This capital represented a 'sunk cost': because of the nature of the undertaking, once resources had been spent on infrastructure they could not be recovered.² Although piped water supply has the characteristics of a natural monopoly, throughout the eighteenth century many parts of London were supplied by several companies and the threat of competition was ever-present.³ For this reason, the companies sought to protect their investments by trying to limit the amount of competition that each faced within their own main area of supply.

In order to limit competition, the water companies colluded in arrangements that prohibited them from undercutting each other in price, which had the result of keeping the price charged for water artificially high. This market structure influenced the relationship between suppliers and customers and, in addition, exposed the companies to political criticism.⁴ With the growing emphasis on market relations and the emergence of the public sphere in the second half of the eighteenth century, the question of monopoly versus

¹ Tarr, J.A., 'Transforming an energy system: the evolution of the manufactured gas industry and the transition to natural gas in the United States, 1807-1954', in O. Coutard, ed., *The governance of large technical systems* (London, Routledge, 1999), pp. 19-37, p. 19.

² Stiglitz, J.E. and Walsh, C., *Principles of microeconomics* (London, Norton, 2006), pp. 42-3.

³ See also Tynan, N., 'Mill and Senior on London's water supply: agency, increasing returns and natural monopoly', *Journal of the History of Economic Thought*, 29 (2007), pp. 49-65.

⁴ Millward, B., 'Emergence of gas and water monopolies in nineteenth-century Britain: contested markets and public control', in J. Foreman-Peck, ed., *New perspectives on the late Victorian economy* (Cambridge, Cambridge University Press, 1991), pp. 96-124; Tarr, 'Transforming an energy system', pp. 19, 32.

market pricing came to the fore and debate arose about the market structure, pricing, and quality of London's water supply. The aim of this chapter is to explore these debates and to understand better the relationships between customers and the water companies.

The reason why these issues became an important topic for public debate relate to the expansion of the commercial water market during the eighteenth century. With the decline of other sources of supply an increasing number of people became dependent on purchasing water from the water companies. As this chapter shows, by the end of the eighteenth century there were some parts of London in which over 80 per cent of houses were connected to a piped supply of water. For many, the decision to connect to the pipe network was a choice made from necessity, as the costs of obtaining water in other ways had risen over and above that charged by the water companies. Some of the opinions expressed in the public press articulated the concern that people were forced to pay what they could not actually afford, which focused attention on the price that the companies charged and the way the market was structured, a pertinent subject of discussion.

This chapter explores the issues raised in the public sphere about the operation of the private companies. In order to do so, it firstly introduces the market forces that structured the eighteenth-century water market; secondly, it examines in closer detail the comments that this structure elicited. Next, to assess how many people were affected by the issues under discussion, the chapter sets out to establish the quantitative importance of the water market, both in term of numbers of customers as well as the price of water itself. Finally, it explores the changes the water market underwent as a result of the concerns raised and market forces involved.

6.1. Buying water: the household economy and the water market.

Access to certain resources, such as shelter, food, and fresh water, is a necessity for survival. However, the form in which these resources are provided depends on circumstances.⁵ As long as water could still be accessed in other ways, a commercial supply was a commodity rather than a necessity, and as such subject to economic decision making processes. There were several alternatives to purchasing water from commercial suppliers in eighteenth-century London. Those who lived close to the Thames or its tributaries could fetch water themselves, although access to the river was not always straightforward.⁶ Rainwater could also be collected but depended on sufficient precipitation and was therefore an unreliable alternative source for a large population. Most parishes provided pumps where water, either provided by the companies or sourced from a spring or deep well, was freely available and supplied to local inhabitants as well as passers-by.⁷ However, these public supplies would have been insufficient to provide for everyone in the parish and fetching water from these sources often necessitated queuing for hours to obtain a supply.⁸

Whether a household was willing to spend this time and effort on fetching water rather than buying it can be broken down as an economic decision. All households need to balance their allocation of productive resources, in other words, the time of its members. Whenever

⁵ Ware, A. and Goodin, R.E., 'Introduction', in A. Ware and R.E. Goodin, eds., *Needs and welfare* (London, SAGE publications, 1990), pp. 1-11, pp. 1-2.

⁶ Jenner, M.S.R., 'From conduit community to commercial network? Water in London, 1500-1725', in P. Griffiths and M.S.R. Jenner, eds., *Londinopolis: essays in the cultural and social history of early modern London* (Manchester, Manchester University Press, 2000), pp. 250-72, p. 250.

⁷ It is impossible to know the total number of pumps and wells in eighteenth-century London, or the amount of people's reliance on them, but they were still in regular use until at least the first half of the nineteenth century. Hardy, A., 'Parish pumps to private pipes: London's water supply in the nineteenth century', *Medical History*, supplement no. 11 (1991), pp. 76-93, p. 80.

⁸ Mayhew, H., *London labour and the London poor: a cyclopedia of the condition and earnings of those that will work, those that cannot work, and those that will not work, volume 1* (London, 1861), p. 194; Jenner, 'Water in London', p. 250.

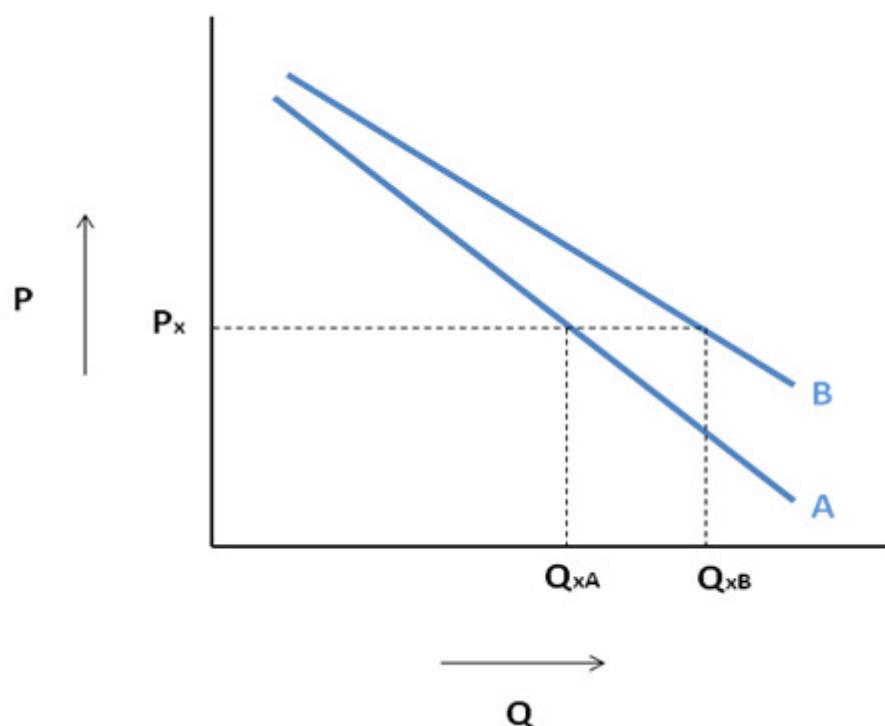
possible, a household will forfeit money-income in order to obtain additional utility and subsequently can spend the time and resources gained by this expenditure on either labour (to gain additional income) or leisure activities.⁹ This transaction would only be favourable to the household if the time and effort to earn the part of money income that is spent on a service (in this case buying water) was less than the utility gained by the hours and industry not spent on producing it within the household (in this case fetching water). Therefore, in household economics, the decision to spend money on a service is dependent on several factors, including the household's budget constraints, the price of the service, and the utility gained by the re-allocation of time and resources.¹⁰

Whether utility can be gained by buying water or fetching it changes according to the wealth of the household and the price of a commercial water supply. Figure 6.1 shows a simple PQ diagram of the water market, in which P (price) represents the price charged for water, and Q (quantity) represents the number of households buying water. Demand curves A and B represent the level of demand at a certain price. Consider demand curve A: at the top end of the curve, with a high price, only a few households will decide that buying water is worth the luxury for them, while households with a lower income would be more likely to invest some of their time and effort in collecting water rather than forfeit precious money income. However, if the price of the water was to drop, there would be a point at which buying water would become more economical for them, and more households would decide to buy water.

⁹ Becker, G., 'A theory of the allocation of time', *The Economic Journal*, 75 (1965), pp. 493-517, p. 498.

¹⁰ De Vries, J., *The industrious revolution, consumer behaviour and the household economy, 1650 to the present* (Cambridge, Cambridge University Press, 2008), p. 25.

Figure 6. 1. PQ diagram for the London water market.



Source: Stiglitz and Walsh (2006), p.57.

Alternatively, if the time and effort required to fetch water were to increase, spending money to buy a water supply instead would free up those resources for the household to allocate to more productive uses. Over the course of the eighteenth century, the dual impact of the decline of public sources and the growing distance to free water sources as a result of the expanding city, led to an increase in household resources needed to fetch free water, which made a commercial supply more cost-effective.¹¹ In this case, the demand curve becomes shallower, depicted in figure 6.1 as curve B. At a certain price level (P_x), more people would be willing to invest in a water supply, shown in the difference between Q_{xA} and Q_{xB} . As a result of the disappearance of free water sources therefore, the

¹¹ This trend continued and by the mid-nineteenth century it was thought that for many domestic users fetching and carrying from standpipes was too costly in time to be economical for households whose members were earning at least the minimum wage. Millward, 'Gas and water monopolies', p. 106.

companies gained more customers, and people were more willing to invest part of their income for a water supply.

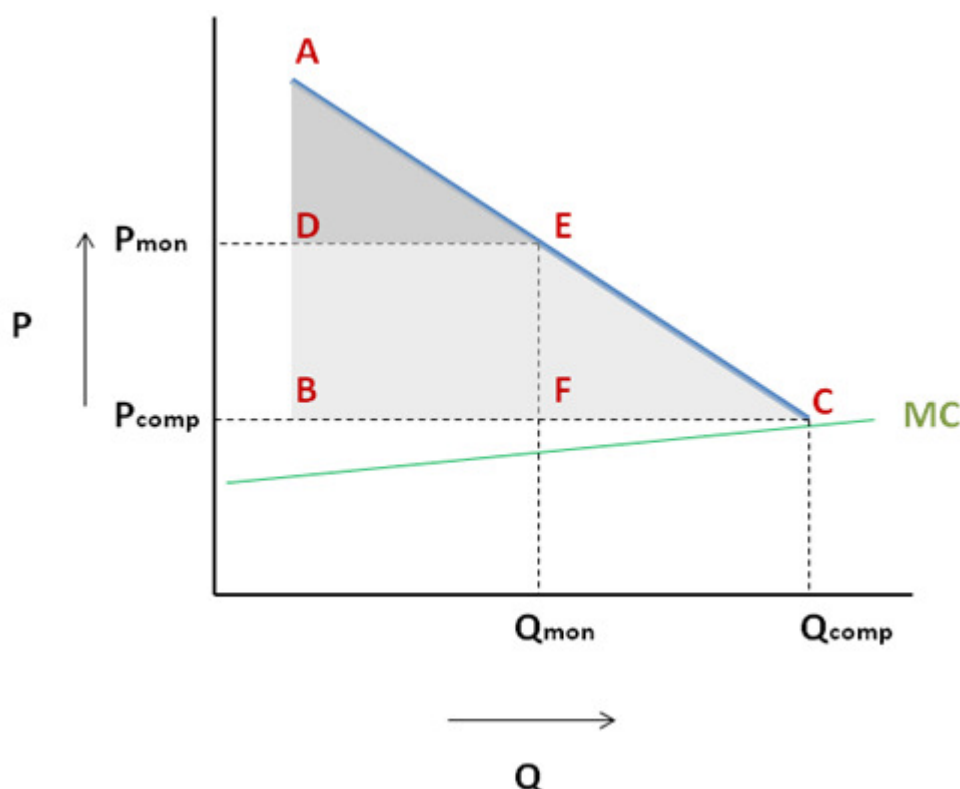
The decision to spend money income on water did not mean that the household could easily afford this, but rather, that it could afford even less to spend time to fetch water. For poorer households, the decision to buy water was only made if there was no real alternative to obtain it for free.¹² For wealthier households, on the other hand, the decision to purchase water was more easily made, as they were giving up proportionally less of their income. Those at the higher end of the curve, who would have bought water even if it was very expensive, still bought it at the reduced price. The utility that they gained from this is represented by the consumer surplus — the area between the demand curve (the price at which consumers were willing to buy) and P_x (the actual price). This surplus is higher for those near the top of the curve, as the difference between willingness and actual price is larger, while for those for whom buying water is only just affordable, the consumer surplus is very low — meaning that a small change in either price, income, or circumstances could lead a household to switch their supply.

So how was the price level determined? Figure 6.2 depicts a simplified model of the water market. MC (marginal costs) depicts the cost for a company to provide a water supply. These costs start at a high level, as the companies had a large investment in their infrastructure, and then rise slowly as more households are added. The costs of adding extra

¹² Not everyone was dependent on public resources: those wealthy enough to afford the investment could dig their own private well. It is unclear how much this would have cost, but 'Curtius' estimated that a private well would pay for itself after 7 years. *Curtius*, letter in the *Morning Post*, 15 Dec. 1775. Many breweries chose this option, as they needed a constant supply and large volumes of water. The downside was that as total water usage in the city increased, the wells were less reliable. *Minutes of evidence taken before the select committee on the supply of water to the metropolis*, PP 1821 (706), p. 117. This is also evidenced by public houses and breweries having a back-up commercial supply in case their wells failed. E.g. LMA/ACC/2558/CH/1/10 Chelsea Waterworks, minutes, 1 April 1748. Similarly, Westminster Abbey had their own conduit supply from springs in Hyde Park, but in 1799 they also applied to have Chelsea water in case their own supply would fail. LMA/ACC/2558/CH/1/16 Chelsea Waterworks, minutes, 26 Sep. 1799.

customers were relatively low, as the most expensive infrastructure (canals, reservoirs, water-raising technology) and the company's running overheads (salaries of managers, collectors, and turncocks) would have been already in place. Additional customers would therefore cost the company only the expenses of the pipes to the new houses as a one-time investment and, after this, raising slightly more water. For simplification, the MC is depicted here in a straight line.¹³ The companies had to recoup these expenses by selling their water.¹⁴

Figure 6. 2. Market model.



Source: Stiglitz and Walsh (2006), p. 291.

¹³ More accurately, this line should be depicted with steps to represent the extra investments needed when extra collectors and turncocks were appointed, or a new technology bought, as discussed in chapter 5.

¹⁴ As they had to spread out the initial costs over their customers, a company would want as many customers as possible. For instance, a waterworks with only 10 customers would be unsustainable, unless these customers would be willing to pay 1/10th each of the infrastructural costs, or if these costs were really low. Companies needed a certain critical number of customers in order to spread the initial costs, after which point additional customers would pay more in rents than their demands cost the company and, therefore, provided a pure profit.

In a perfectly competitive market, the price of water to one household would equal the marginal production costs, in other words, this household's share in paying-off the initial outlay (infrastructure, maintenance, and managerial overheads) plus the cost of supplying the household itself. This meant that the company would be reimbursed for the costs of supplying water, would pay all of its employees a salary, but would not run a profit. This is the cheapest price at which a water supply could be produced without the company making a loss, and in a perfectly competitive market, the price can be driven down to this level. In figure 6.2, this price level is represented by P_{comp} .

In a non-competitive market however, companies can establish a higher price, in figure 6.2 depicted as P_{mon} .¹⁵ This higher price has several consequences. Firstly, the company makes a profit from the price difference between P_{comp} and P_{mon} . Secondly, a part of the population that bought water at the lower P_{comp} will no longer find it affordable to buy water at P_{mon} , and move to fetching water (the difference between Q_{mon} and Q_{comp}). Thirdly, the consumer surplus for those that still buy water at P_{mon} decreases accordingly: while at P_{comp} level the consumer surplus is the whole shaded area ABC, at P_{mon} the consumer surplus decreases to the smaller darker shaded triangle ADE. This implies that the whole area DEBC was lost to the water consumers as a result of the higher price. Part of this lost area, the square DEBF, is converted straight into profits for the company.¹⁶ It represents a profit solely due to a company's power to set a monopoly price, without having to produce anything extra, and therefore means a loss to the water consumers, as they paid

¹⁵ In which mon stands for monopoly. As we will see, during the eighteenth century the water market was not purely a monopoly, but in certain areas it had oligopoly characteristics. An oligopoly price can be as high or only slightly below the monopoly price.

¹⁶ The other part of the consumer surplus' loss, the triangle EFC, is described as the deadweight loss. This represents potential production which is not realised in a monopoly situation, as it would not be profitable to the monopolist company. It implies a loss to society without any gain to the monopolist company. These costs are in fact not as large as depicted in the model, and have been estimated to be about 3% of the monopolist's output value. Stiglitz and Walsh, *Principles*, p. 290.

the company for its profits without gaining any extra utility. The public's interest was to ensure that the water price approximated the producer's cost of supply, which would increase the consumer surplus.¹⁷ For a company to earn profits without an increase in benefit for the consumers (and indeed a loss, as for some the water had become unaffordable) was seen as unfair and unearned, and as a result, the P_{mon} was seen as an unfair price, as opposed to the lower P_{comp} that allowed the companies just compensation for their work. As a result, it was this area, represented by DEBF, that came to be contested by people who agitated against the market structure that enabled the higher prices to be charged.

A high price like the P_{mon} could not be kept up under competitive market circumstances, as competitors could undercut each other in order to gain new customers, which would eventually drive down the price to P_{comp} . Monopolistic or oligopolistic market conditions were required to keep the price at a higher level. That this price was kept up (at close to the P_{mon} level) for most of the eighteenth century, is evident from the actions of the water companies.

There were several strategies to ensure that high prices prevailed. Firstly, companies could collude to set the price together. This appeared to have been a common strategy in the eighteenth century, much in evidence in the coal trade where the 'Limitation of the Vend' operated, but evident in other activities as well.¹⁸ Arrangements of this nature drew comment from Adam Smith, who remarked that "people of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy

¹⁷ Millward, 'Gas and water monopolies', p. 109

¹⁸ See e.g. Cromar, P., 'The coal industry on Tyneside, 1771-1800, oligopoly and spatial change', *Economic Geography*, 53 (1977), pp. 79-94; Randall, A. and Charlesworth, C., eds.: *Markets, market culture and popular protest in eighteenth-century Britain and Ireland* (Liverpool, Liverpool University Press, 1996).

against the public, or in some contrivance to raise prices”.¹⁹ Secondly, companies could act to prevent new entrants to the market by temporarily lowering prices in order to retain their market share. In this situation, unless backed by considerable reserves of capital, the high initial outlay on creating a new waterworks meant that newcomers would have found it difficult to make sufficient profits to make it worthwhile the risk and were discouraged from entering the market. Finally, companies could anticipate the actions of their rivals, and counter them with similar price increases and decreases, which would equally benefit all companies involved.²⁰ At various times, the existing companies used all of these tactics to counter the threat of competition, both from new entrants to the market as well as from each other.

The competitive pressures were greatest in those areas where multiple companies had pipes and where there was always the possibility of competition.²¹ One of the largest areas where this situation prevailed was the City of London, which was supplied both by the London Bridge Waterworks as well as the New River Company. In 1738 an agreement between the two noted that “it was judged highly proper and convenient and for the mutual advantage of each society” to avoid taking each other’s customers. This agreement also included a promise not to sabotage each other (“not to take ferules out of other mains or pipes and remove them”), not to take on customers until they had settled their arrears with the other company, nor to employ “false pretenses or clandestine means to be used to gain or persuade any to become tenants by underletting or otherwise”.²² While a customer could switch as long as they had paid their arrears, the agreement effectively prevented each

¹⁹ Smith, A., *The wealth of nations*, p. 111.

²⁰ Stiglitz and Walsh, *Principles*, p. 275.

²¹ *Ibid.*, pp. 274-5.

²² LMA/ACC/2558/MW/C/15/291 Agreement between London Bridge Waterworks and the New River Company, 1738.

company from lowering its price as a way of enticing more customers to take up a supply. This contract was taken seriously and was binding. When in 1781 the managers of London Bridge Waterworks realised that a collector of the New River Company was taking over London Bridge customers by undercutting them in price, the contract was called in. In response, the New River Company's directors instructed their collector not to offer lower prices to London Bridge customers, as they wanted to keep up the "good relations between the companies".²³

Given the opportunity, customers in a position to switch suppliers could always apply to do so. However, when this occurred, the companies usually checked with their previous supplier, partly to ensure that the customer was not in arrears, in which case their custom would pose a risk to the new company, but also to prevent taking customers from each other without good reason. When in the early 1790s customers of York Buildings Waterworks applied to switch to the New River Company because they were unhappy with their water service in the Strand, rather than taking these on, the directors of the New River Company informed York Buildings of this issue.²⁴ A year later it was reported back that York Buildings had improved their service and that customers on the Strand were now happy to remain there.²⁵ In the same way, West Ham Waterworks warned the New River Company when some of its customers in Whitechapel had applied to switch to their supply.²⁶

This practice allowed companies to rectify causes for complaints, and the collaboration protected them against the loss of customers arising from unforeseen circumstances. When London Bridge Waterworks was damaged by a fire in 1779, the New River Company

²³ LMA/ACC/2558/LB/1/3 London Bridge Waterworks, minutes, 27 April 1781 and 4 May 1781.

²⁴ LMA/ACC/2558/NR/1/3 New River Company, minutes, 17 May 1792.

²⁵ Ibid., 2 May 1793.

²⁶ LMA/ACC/2558/NR/1/2 New River Company, minutes, 26 Sep. 1782.

informed its rival's managers that it had received lots of applications from people wanting their water. As the New River Company's directors, whose headquarters had burnt down a decade previously, were "by no means desirous of taking any advantage of the Misfortune that has happened to the work", they enquired how to proceed with these applications.²⁷ London Bridge's managers were grateful and sent them a list of customers who would have been affected by the fire. The New River Company did not take these people on, and London Bridge's water supply was up and running again within a few weeks.²⁸ A similar situation arose with the Shadwell Waterworks when London Bridge Waterworks' pipes were frozen and the company could not supply sugar bakers in Well Close Square. Rather than taking over the customers, the Shadwell company supplied them until London Bridge Waterworks could do so again.²⁹ Short term gain, in both cases, was set aside in favour of longer term arrangements that were considered to have been more important in preserving profits.

In 1789, the New River Company decided to take on customers that came from another water company, but the reaction it received suggested that this action ran counter to the unwritten rules.³⁰ The managers of Hampstead Waterworks, the previous supplier of the contested customers, complained to the New River Company as they believed that these customers had had no reason to abandon their Hampstead supply, but only wanted to move supplier because one of the landlords had been in a conflict with the company. The directors of the New River Company refused to let the new customers go and emphasised

²⁷ LMA/ACC/2558/LB/1/2 London Bridge Waterworks, minutes, 10 Nov. 1779.

²⁸ Ibid.

²⁹ LMA/ACC/2558/LB/1/4 London Bridge Waterworks, minutes, 20 Feb. 1795.

³⁰ There is no evidence of a contract between the New River Company and Hampstead Waterworks.

that they were paying the same price as they had previously paid to Hampstead.³¹ This implies that while the switching of these customers would have been a dubious practice in light of the companies' good relations with each other, competing on price would have definitely gone against the nature of these relations.

Whilst cooperation was a means of protecting profits, there were times when companies needed to raise prices, in which case they had to persuade their rivals to do likewise or face the prospect of competing with each other on price. This situation arose in 1783 between London Bridge Waterworks and the New River Company. London Bridge Waterworks decided to raise the water-rent of a sugarbaker in Queen Street from £10 to £14 per annum, as it believed they worked more pans and thus consumed more water than initially calculated. In response, however, the customer switched to the New River Company, which offered them an annual rent of £12. The justification the New River Company used for taking on the new customer was that because the company was actually offering a price above what the customer had previously paid for water, its actions could not be construed as undercutting London Bridge Waterworks.³² If there was no agreement between the companies, the potential for competition was far higher and profit margins became less secure as a result. On other occasions, therefore, companies raised prices together when one had the need to increase its charges. This situation arose in 1799 when the Borough Waterworks wanted to increase its rents in south London, but needed London Bridge Waterworks to do the same, and London Bridge's managers decided to oblige in order to maintain the "harmony between the companies".³³

³¹ LMA/ACC/2558/NR/1/3 New River Company, minutes, 19 Nov. 1789.

³² LMA/ACC/2558/LB/1/3 London Bridge Waterworks, minutes, 30 May 1783.

³³ LMA/ACC/2558/LB/1/5 London Bridge Waterworks, minutes, 29 March 1799.

Under oligopolistic conditions, such as those discussed above, even though the cartel price was higher than a competitive price would be and companies could, if they wished, have lowered their prices and still make a profit, it was not in their interests to do so. However, whenever a new entrant to the market appeared, the situation could alter and competition could ensue. New entrants, keen to carve out a customer base from those supplied by the older companies, could benefit by acting competitively to attract new tenants.³⁴ For example, when Chelsea Waterworks entered the West End market, its main competitor was the New River Company.³⁵ During the late 1720s and 1730s these two companies competed to divide the West End market between them.

It was not unusual for more than one company to operate in the same streets: in 1727 the New River Company complained that the new Chelsea company was laying pipes over theirs.³⁶ This gave consumers the option of playing off both companies against each other. In 1726, residents of St James Square were negotiating with both the New River Company as well as Chelsea Waterworks for cheaper rents. The Commission for Embellishing St James Square was planning a basin in the square, and Chelsea Waterworks negotiated to meet any deal they had with the New River Company and threw in the filling of the basin for free.³⁷ Eventually both companies supplied houses in this square and several years later, a resident named John Heathcote made a case to refuse to pay Chelsea Waterworks more than £4 per year as that was the price which the New River Company's customers paid, and this had

³⁴ Stiglitz and Walsh, *Principles*, p. 275.

³⁵ They had taken over the smaller concerns of Millbank and Hyde Park waterworks. At this time York Buildings Waterworks was embroiled in its failed experiment with the steam engine, and could not engage in competition with the new company. In fact, many York Buildings' customers that were supplied from the upper reservoir, which had to be given up with the steam engine, applied to Chelsea Waterworks. Another potential competitor was Marchants's Waterworks, which at some point between the drawing of the Rocque map and the 1770s ceased business. This company was never mentioned in the Chelsea Waterworks' minutes and was either a very small undertaking or only supplied in an area that did not border Chelsea Waterworks.

³⁶ LMA/ACC/2558/CH/1/2 Chelsea Waterworks, minutes, 23 Nov. 1727.

³⁷ LMA/ACC/2558/CH/1/1 Chelsea Waterworks, minutes, 4 Aug. 1726.

encouraged some customers to switch. The Chelsea's directors accepted that their customers could pay the same as their neighbours were charged by other companies, and lowered Heathcote's price.³⁸ Similarly, when Mr Jesse of Piccadilly had his rent doubled by Chelsea Waterworks and threatened to go to the New River Company, the rent was lowered again.³⁹

After the 1730s, by which time the Chelsea Waterworks had managed to establish itself, examples of competition such as those mentioned above no longer appeared in the directors' minutes, even though the company still supplied the same areas as the New River Company. While there is no evidence that a formal contract was made between the two companies, the directors of both realised that competing on price was not beneficial for business. However, in 1748 the York Buildings Company had recovered from its earlier financial troubles and, having no other way to expand, it started to encroach on streets in Westminster which had been supplied by Chelsea Waterworks, offering a price of four shillings in the pound less than its competitor. At a meeting of Chelsea Waterworks' directors, it was reported that many people were switching suppliers, a situation that caused some alarm, as it was estimated that the company had already lost an income of £140 as a result. In response, the directors thought it prudent to lower their price rather than risk losing customers and decided to charge the same as York Buildings Waterworks.⁴⁰ By doing this, neither company gained any significant number of new customers, and both decreased their profit margin. This case shows how competition could be beneficial for the customers, as they were charged the lower P_{comp} , which came at a cost to the companies.

³⁸ LMA/ACC/2558/CH/1/6 Chelsea Waterworks, minutes, 31 March 1735.

³⁹ LMA/ACC/2558/CH/1/7 Chelsea Waterworks, minutes, 21 April 1736.

⁴⁰ LMA/ACC/2558/CH/1/10 Chelsea Waterworks, minutes, 13 May 1748.

As a result, this period of competition was relatively short-lived and in 1760 York Buildings informed Chelsea that it was reverting its charges back to the original price. Perhaps with some relief, the Chelsea directors followed suit saying they “won’t charge houses any less rent” than their competitors.⁴¹ While the competition might have allowed customers to reduce their expenses for a while, competing on price was in neither of the companies’ interest and by 1776 there was talk between the companies of making a similar agreement as that which existed between the New River Company and London Bridge Waterworks.⁴²

The introduction of other new companies in the 1740s elsewhere in the city created similar kinds of disruption to the existing arrangements. In east London, the newly formed West Ham Waterworks, established in 1743, encroached on the area supplied by Shadwell Waterworks, the directors of which had sought to prevent the newcomer from becoming established. However, once formed, both companies realised that it was in neither’s benefit to compete and, eventually, they agreed to demarcate areas of supply.⁴³ The deed that settled this arrangement dates from 1785, although it stated that the agreement had been in place for a while. In the deed, Shadwell Waterworks agreed to buy all West Ham’s pipes in the lower district over a period of five years, and for at least the first year it had to reimburse West Ham Waterworks for the expenses of coals and the turncock used for the supply of this area. As there was no similar arrangement north of the demarcation line, the deed suggests that Shadwell simply bought out West Ham Waterworks in the lower district in order to become the monopoly supplier in the area.⁴⁴

⁴¹ LMA/ACC/2558/CH/1/12 Chelsea Waterworks, minutes, 23 April 1760.

⁴² LMA/ACC/2558/CH/1/13 Chelsea Waterworks, minutes, 4 Jan. 1776.

⁴³ LMA/ACC/2558/EL/A/2/B28/1 Agreement between West Ham Waterworks and Shadwell Waterworks, 1785.

⁴⁴ Ibid. Shadwell Waterworks had to pay £5,000, as well as £315 a year.

Similar sets of concerns motivated arrangements south of the river, where there was opposition to the Lambeth Waterworks which started up in 1785. London Bridge Waterworks managed to get a clause in the new company's Act of Parliament that prevented it from laying pipes in paved streets in the borough of Southwark, which essentially were those streets that London Bridge Waterworks already supplied.⁴⁵ Both in the east as well as in the south, therefore, by the end of the eighteenth century effective spatial monopolies had been set up, in which companies could set a higher price than would otherwise have been the case under more competitive arrangements. In the early nineteenth century the rest of London would follow this pattern as well.

For most of the eighteenth century, however, even in the areas where multiple companies supplied, the price was artificially kept high in an oligopoly price, through agreements and collaboration between the companies. These practices meant that for long periods during the eighteenth century the consumer surplus was reduced, and part of what customers paid were straight profits for the companies. This situation, in turn, stimulated a growing volume of public debate about what was a fair price, what should be the water market structure and what was the position of the companies.

6.2. Published opinions on the water market.

In 1790 John Robins, an inhabitant of Ratcliffe, published the pamphlet *'A bone to pick - recommended to the several water Companies of this metropolis; or a check to Avarice,*

⁴⁵ LMA/ACC/2558/LB/1/3 London Bridge Waterworks, minutes, 16 March 1787.

Tyranny and Oppression'.⁴⁶ His argument was especially directed towards the proprietors of Shadwell Waterworks who, as he claimed, had exhibited "arbitrary and insolent behaviour to their customers (...) enforcing compliance to their unreasonable and unjustifiable demands".⁴⁷ By means of a "Diabolical Combination" this company had been able to make their customers pay whichever price it imposed on them, which Robins objected to.⁴⁸ He presented his own case as an example: as a customer of Shadwell Waterworks, he had been subjected to several price increases for his water; in 1772 he paid 10s per year, which in 1777 went up to 14s, and by midsummer 1778 to 15s.⁴⁹ Robins attributed these increases to the understanding between Shadwell and West Ham Waterworks, noting: "this is the blessed effect of monopoly".⁵⁰

Robins paid the increased price without complaints. However, in 1785 the company raised his water-rent again, to 18s, which the company justified on account of "Expenses & Losses".⁵¹ This time, Robins refused to pay the new and higher price and decided to continue paying at the level of his old rate.⁵² In response, Shadwell Waterworks summonsed him for non-payment. The reasons that Robins stated in court for his refusal to pay, as well as in the pamphlet, reveal his concerns about the water companies' monopoly. He explained that though he thought it reasonable that the proprietors could derive an income from their

⁴⁶ Robins, J., *A Bone to Pick, Recommended to the Several Water Companies of this Metropolis; Or a Check to Avarice, Tyranny and Oppression, in Two Parts* (London, 1790).

⁴⁷ *Ibid.*, pp. 6-7.

⁴⁸ *Ibid.*, p. 13.

⁴⁹ *Ibid.*, p. 15.

⁵⁰ *Ibid.*, p. 15. While it is possible that the companies already had an agreement around this time (the 1785 formal deed was unspecific as to when the arrangement started) it is also possible that the rise was a result of the company's struggles with its rival. As John Robins did not mention the possibility of moving to West Ham Waterworks, it can be deduced this company did not supply his street. It is therefore possible that Shadwell Waterworks, in order to be able to offer a competitive price in the streets where the other company was present, rose its charges in streets where it had a monopoly position. As a result of the lack of sources on the eastern companies, this remains speculation.

⁵¹ *Ibid.*, p. 15. Probably related to the agreement with West Ham Waterworks.

⁵² *Ibid.*, p. 19.

works, not only to pay their employees and keep the infrastructure in good repair but also as an interest for their investment, it seemed to him that their income exceeded this.⁵³ He refused to pay the new increased price, as he thought it was “arbitrary” and would add too much to the company’s profits, which he considered “very excessive”.⁵⁴ He decided to continue paying at the level of his old rate as he only wanted to pay a price that was “reasonable and just”.⁵⁵

The court, however, ordered Robins to pay the full price. As he still refused, the company cut off his supply in 1788, after which Robins had to rely on fetching water from the Thames.⁵⁶ The decreased customer surplus under monopoly pricing is exemplified by John Robins’ decision to fetch water from the Thames rather than pay the increased charge. While he had been happy to invest household money in a water supply up to a certain point, as its price increased while utility gained from the service remained the same, he had reached the point at which he would rather fetch water from the Thames than pay over the production price to Shadwell Waterworks.

While John Robins lived near the Thames and fetching water did not mean too much of a loss of household resources, not everyone had this opportunity. Two authors who published letters in the *Morning Post* sixteen years previously addressed the effects the market structure had on areas where people had no alternative to paying whatever the companies charged. In December 1775 a letter appeared in the *Morning Post* written by ‘Curtius’, who addressed the water supply of Westminster.⁵⁷ He questioned “what other alternative the poor or rich on the upper side of Westminster-bridge have, than that of paying whatever

⁵³ Robins, *Bone to pick*, p. 50.

⁵⁴ *Ibid.*, p. 6.

⁵⁵ *Ibid.*, p. 19.

⁵⁶ *Ibid.*, p. 35.

⁵⁷ Curtius, letter in *Morning Post and Daily Advertiser*, 15 Dec. 1775.

[Chelsea Waterworks] chuse arbitrarily to fix, or else be necessitated to go to the Thames at high water for their supply”.⁵⁸ While people could still go to the river for a supply, there were few other options: “Are not the greatest part of the common pumps destroyed, which renders the oppression on the poor effectual? (...) how many poor people are compelled to pay, whose back and bellies cannot spare it without being pinched?”⁵⁹ Because the lack of other ways to source water, a company supply had become a necessity rather than a luxury, which made the market structure’s effects on the poorer households especially a cause for concern.

Another author, signed ‘*Aquae Vindex*’, wrote to the same paper setting out similar concerns about the price that the poor were forced to pay, as there was not enough water freely available.⁶⁰ This writer saw the commercial water supply solely as a luxury and believed that no one should be compelled to pay for water except “*the conveniency of having it conveyed into their houses*”.⁶¹ As he recognised that this provision entailed expense, he was happy for the companies to exist and even run at a profit, but he also insisted that “water ought to be free to all, who will take the pain to fetch it! — None ought to be compelled to have the water laid in”.⁶² In other words, whilst the conveyance of water to homes was considered a legitimate service that consumers could choose to purchase, the actual supply of water at its source should remain freely available, leaving households to choose whether or not to invest their resources in fetching it or having it brought to their homes through the piped network.

⁵⁸ Curtius, letter in *Morning Post and Daily Advertiser*, 15 Dec. 1775.

⁵⁹ Ibid.

⁶⁰ *Aquae Vindex*, letter in *Morning Post and Daily Advertiser*, 14 Dec. 1775.

⁶¹ Ibid. Cursive in the original.

⁶² Ibid.

Both *Aquae Vindex* and *Curtius* attacked the companies because the way they managed their water gave them the power to decide who was able to access it. *Aquae Vindex* called the directors of these companies “covetous, mercenary men”, who monopolised and dominated the inhabitants through the prices they set, and cut off those who could not pay.⁶³ He accused the companies of withholding their water, as they “lock the water at every corner of the street”, and prosecuted people who shared their (bought) water with the poor.⁶⁴ *Curtius* described the supply of lower Westminster as a “matter of aquatic tyranny” and complained that “the managers of the Chelsea water-works, or their agents, sensible that there is no alternative, upon the least altercation relative to charges, will tell you you shall have none, and they will cut [the water off].”⁶⁵

6.3. London’s water market: extent.

The concerns expressed by *Aquae Vindex* and *Curtius* reflected the fact that people were increasingly forced to buy water only because there were no adequate alternatives. Considering the size of the water market by the end of the eighteenth century, this seems to have been a valid concern. An assessment of the number of people and the kind of houses supplied by the companies suggest that a piped water supply was not just a luxury for the wealthy, but a common occurrence for large numbers of houses and inhabitants in eighteenth-century London.

⁶³ *Aquae Vindex*, letter in *Morning Post and Daily Advertiser*, 14 Dec. 1775.

⁶⁴ *Ibid.* This is likely to be a reference to the practice of making tenants lock up access to their cisterns, so they could not share with others, as discussed in chapter 5.

⁶⁵ *Curtius*, letter in *Morning Post and Daily Advertiser*, 15 Dec. 1775.

Estimating the size of the eighteenth-century London water market is difficult because many of the companies' early customer records have not survived. However, piecing together information from a variety of sources, it is possible to make an approximate estimate of the extent to which a commercial water supply was provided to the population. At the start of the century most of the waterworks were still rather small concerns, with a few thousand local customers at the most. For some companies lists of tenants have survived. In the western part of the metropolis, Hyde Park Waterworks supplied approximately 500 houses in 1678, while Millbank Waterworks supplied 1,250 in 1715.⁶⁶ In the east, Shadwell Waterworks had around 1,300 customers in 1720.⁶⁷ Audits of the New River Company, which by then still mainly supplied the City, suggested that in 1684 it had roughly 3,000 tenants.⁶⁸ Only rough estimates can be made for the remaining companies, York Buildings, Marchant's, and London Bridge Waterworks, but they were unlikely to have supplied more than a couple of thousand of houses each. Tax records from 1677 indicate that market penetration in the City of London, which was supplied by London Bridge, Broken Wharf, and the New River Company combined, varied between 30 per cent of houses in the poorer wards to no more than 60 per cent in the more affluent wards.⁶⁹

A very different picture emerges at the end of the eighteenth century. In a 1821 Parliamentary enquiry on London's water supply, the companies north of the river had been asked to submit to a Select Committee, amongst other records, the number of houses they

⁶⁶ Westminster Archives, F2489, Hyde Park Waterworks, list of tenants, 1678; LMA/ACC/2558/MW/C/15/99 Millbank Waterworks, list of tenants, 1715.

⁶⁷ LMA/ACC/2558/MW/C/15/98 tenants of Shadwell Waterworks, 1720.

⁶⁸ Rudden, B., *The New River, a legal history* (Oxford, Clarendon Press, 1985), p. 35.

⁶⁹ Jenner, 'Water in London', p. 257.

supplied at various points in time.⁷⁰ The furthest back this information went was 1804. In that year, the New River Company supplied 54,681 houses, York Buildings Waterworks 2,089 buildings, while Chelsea Waterworks supplied a total of 8,330 dwellings, and 94 'other buildings'.⁷¹ The size of the other companies at the turn of the century has to be estimated as only later figures are available. London Bridge Waterworks reported that over 10,000 houses were supplied in 1810, 60 per cent of which were north of the river Thames.⁷² The company's expansion strategy at the time had been focused on the south, and assuming that it had indeed been expanding between 1804 and 1810, the number of customers in the City can be roughly estimated at about 5,000.⁷³

Farther east, the East London Waterworks bought both Shadwell and West Ham Waterworks in 1808, at which time Shadwell supplied 8,000 houses and an unquantified number of industries, while West Ham supplied 2,250 houses.⁷⁴ It has been suggested that between 1804 and 1809 about 1,500 customers were displaced by the construction of the London Docks, which would have especially affected Shadwell Waterworks.⁷⁵ However, East London Waterworks' engineer reported in 1808 that Shadwell Waterworks was supplying at the full capacity of its powers and could not expand, so it is not clear how it could have supplied an extra 1,500 houses only four years previously.⁷⁶ While for table 6.1 and the

⁷⁰ *Select committee*, PP 1821 (706). This enquiry was undertaken to evaluate the impact of the 'waterwars' of the early nineteenth century, and the water companies were required to supply information about their business before a period of competition commenced in 1811. The only company that supplied north of the river and was not subject to this investigation was Hampstead Waterworks, for which there are no other records available and therefore has been omitted from this analysis.

⁷¹ *Select committee*, PP 1821 (706), pp. 207, 215, 225.

⁷² Estimated based on 1821 numbers, when the company had 10,417 customers (only 100 more than in 1810), of which 3,813 was based in Southwark. *Select committee*, PP 1821 (706), pp. 202, 245.

⁷³ London Bridge Waterworks' income from water-rents rose from £11,054 to £12,589 between 1804 and 1810, but this did not necessarily mean expansion as they had raised their prices at this time. *Select committee*, PP 1821 (706), p. 200.

⁷⁴ LMA/ACC/2558/EL/A/1/2 East London Waterworks, minutes, 17 March 1808.

⁷⁵ *Select committee*, PP 1821 (706), p. 245.

⁷⁶ LMA/ACC/2558/EL/A/1/2 East London Waterworks, minutes, 17 March 1808.

following calculations the 8,000 number has been accepted, it should be noted that there is a possibility that the number of houses supplied in east London was even greater.

Table 6. 1. Estimation of houses supplied in 1804.

Company	Estimated houses supplied in 1804
New River Company	54,681
Chelsea Waterworks	8,330
York Buildings Waterworks	2,089
London Bridge Waterworks	5,000
Shadwell Waterworks	8,000
West Ham Waterworks	2,250
Total	80,350

Source: Select Committee, PP 1821 (706); East London Waterworks minutes, LMA/ACC/2558/EL/A/1/2, 17 March 1808.

Adding up these numbers makes a grand total of over 80,000 houses north of the river supplied with commercial water at the start of the nineteenth century (see table 6.1).⁷⁷ This was quite a large proportion: an estimate of the number of houses in 1804 based on the 1801 and 1811 censuses shows that (including uninhabited houses) there were about 105,000 houses in the area that these companies could have covered.⁷⁸ Thus, overall, approximately three-quarters of houses in this area received commercial water by the end of the eighteenth century.

These numbers mean that over the course of the eighteenth century the companies dramatically expanded their supply. Further evidence for this can be found in the records of

⁷⁷ Certain houses would have received water from more than one company, however the total of these was probably quite small.

⁷⁸ Based on the 1801 census enumeration abstracts, with 3/10ths of the difference between the 1801 and 1811 censuses added. This is the total of the number of houses in the Cities of London and Westminster, and out-parishes in Middlesex: Finsbury, Holborn, Kensington and the Tower divisions (with the exception of parishes which were too far north to receive London's water, such as Fryern Barnet and Hornsey). The number includes c. 4,000 houses which were uninhabited or being built at the time. Census of England and Wales, 1801, *Enumeration abstract, Middlesex*, PP (497), pp. 207-16; Census of England and Wales, 1811, *Enumeration abstract, Middlesex*, PP (497), pp. 192-9.

the New River Company, for which detailed customer information is available based on half-yearly water-rents paid in 1769.⁷⁹ Over 26,000 people paid rent to the company in that year, but this did not equal the number of houses supplied. Landlords ‘farmed out’ water-rents by paying the company for multiple houses whether these were inhabited or not, and then charging the tenants for water, usually included in the rent. This was a common practice across all companies.⁸⁰ It is therefore difficult to ascertain the number of houses that the New River Company supplied in 1769 but, fortunately, the number of tenants in 1804 is available: 38,403 (see table 6.2). In terms of water-tenants the company’s growth between 1769 and 1804 is therefore clear: over 12,000 tenants were added in these 35 years. Compared with the 3,000 customers the company had supplied 100 years previously, these numbers indicate that during the eighteenth century the New River Company had been constantly and steadily expanding its market.

In terms of geography, the New River Company’s reach in 1769 is shown in figure 6.3. The map depicts the area that the company supplied, with each circle representing a street in which the company’s tenants lived. This figure has been based on the addresses of those who paid for the water, and in certain areas this differed from those who actually received it. As the 1804 data in table 6.2 show, the number of houses per tenant varied distinctively between the collection districts.⁸¹ Most water-tenants in the western districts, for example the Portland and Marylebone collections, only paid for their own house, while those in the east of the capital averaged two or more houses as a result of the farming out of water-

⁷⁹ LMA/ACC/2558/NR/12/1 New River Company, rent book, 1769.

⁸⁰ For example, in 1741 Mr Littehalé supplied St John Street in Westminster with Chelsea water, paying the company £12 10s a year. He supplied 25 houses from this water, of which he owned 21 himself and the other 4 paid him 10s rent each. This also left him with 10s for each of his own houses, which he presumably charged to his tenants. LMA/ACC/2558/CH/1/9 Chelsea Waterworks, minutes, 27 May 1741.

⁸¹ The only district in which tenants as a group owned fewer houses than their own number occurred on the banks of the New River canal. This was a constant over the recorded years until 1819, and could be explained by farmers or landowners purchasing water for their lands or recreational use alongside the canal.

rents.⁸² While the number of houses per tenant is not available for 1769, it can be assumed that similar ratios occurred. This has implications for the map shown in figure 6.3: while the western part accurately represents the streets in which the New River Company not only had tenants, but also actually supplied, in the eastern part of the map, the streets in which the company supplied is under-represented, as the data only shows those users who paid directly to the company.

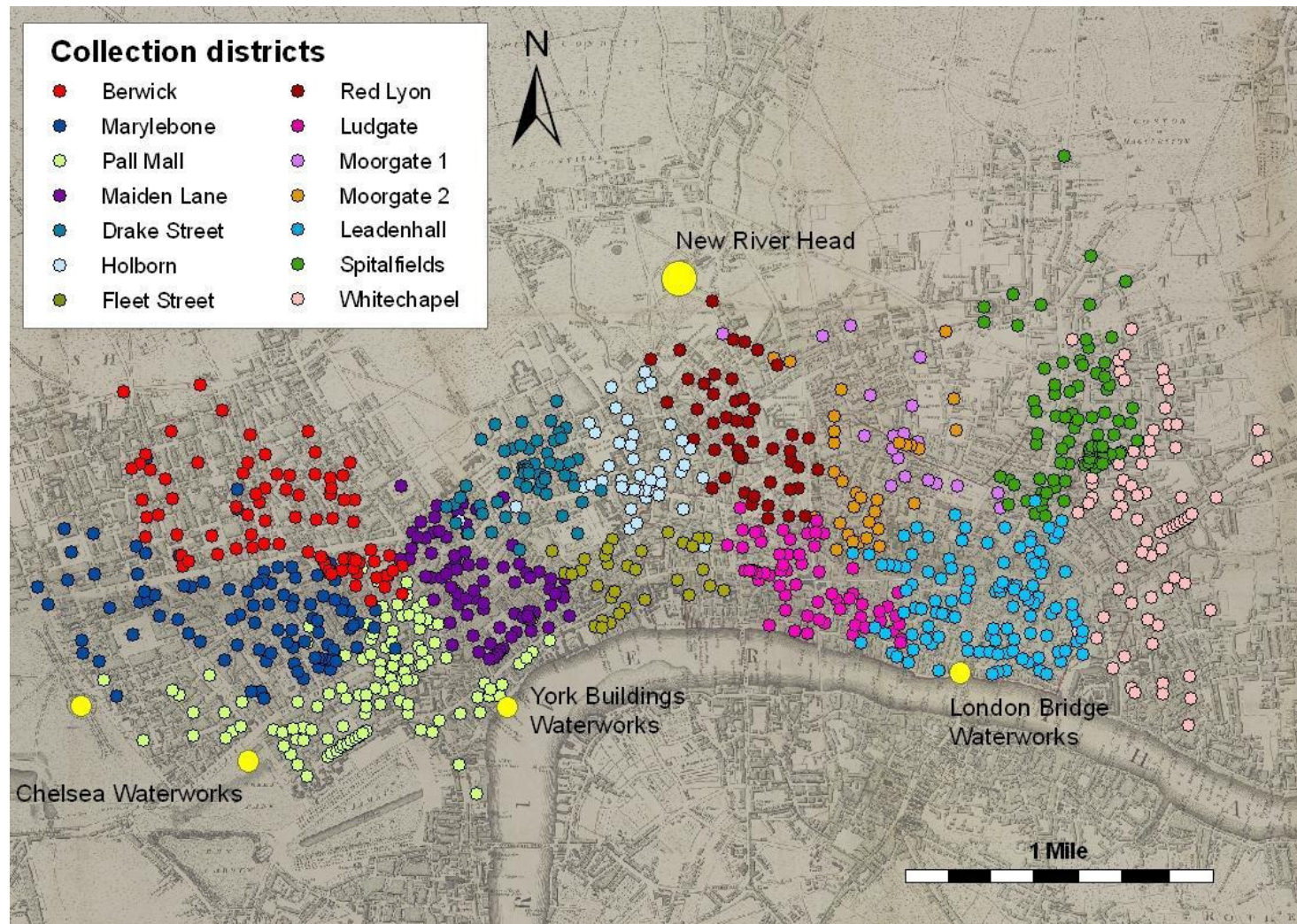
Table 6. 2. New River Company number of tenants and houses, 1769 and 1804.

1769		1804			
Districts	Tenants	Districts	Tenants	Houses	Houses/tenant
Berwick Street	2,053	Portland	2,940	3,030	1.03
Marylebone	2,227	Marylebone	3,675	3,723	1.01
Pall Mall	2,228	St James	2,464	2,576	1.05
Maiden Lane	2,156	Covent Garden	2,242	2,612	1.17
		Soho	2,386	2,591	1.09
Drake Street	1,925	Bloomsbury	3,292	3,768	1.14
Holborn	1,612	Holborn	2,011	3,241	1.61
Fleet Street	2,273	Fleet Street	1,918	2,170	1.13
Red Lyon	2,337	Clerkenwell	2,461	4,312	1.75
Ludgate	1,644	St Pauls	1,903	2,278	1.20
Moorgate 1	1,451	Islington	3,090	4,727	1.53
Moorgate 2	1,090	Moorfields	2,436	5,160	2.12
Leadenhall	1,759	Cornhill	2,302	2,954	1.28
Spitalfields	1,806	Shoreditch	2,768	5,545	2.00
Whitechapel	1,635	Whitechapel	2,366	5,890	2.49
		River Bank	149	104	0.70
Total	26,197		38,403	54,681	1.42

Source: Select Committee, PP 1821 (706), p. 207; New River Company, 1769 rent book, LMA/ACC/2558/NR/12/1.

⁸² In these districts, the larger ratios were likely caused by a few landlords farming out a large number of houses.

Figure 6. 3. Distribution of New River Company's tenants in 1769.



Source: New River Company, 1769 rent book, LMA/ACC/2558/NR/12/1. Base-map is the Stockdale map of 1797.

Still, the figure shows that the New River Company had an enormous spread over north London, at quite a distance from the reservoir at the New River Head from where the water was pumped into the mains. The network also reached into the areas that other waterworks supplied: there were New River customers in streets near the Thames in the City, supplied by London Bridge Waterworks, as well as near the intake of York Buildings and the reservoirs of Chelsea Waterworks.

For Chelsea Waterworks, more detailed information is available as well. This company recorded its number of customers on a parish level and these can be compared against the census. The company's market penetration of the parishes it supplied is shown in table 6.3 and figure 6.4. As the census only counted residential property, this table is based on the number of domestic customers only.

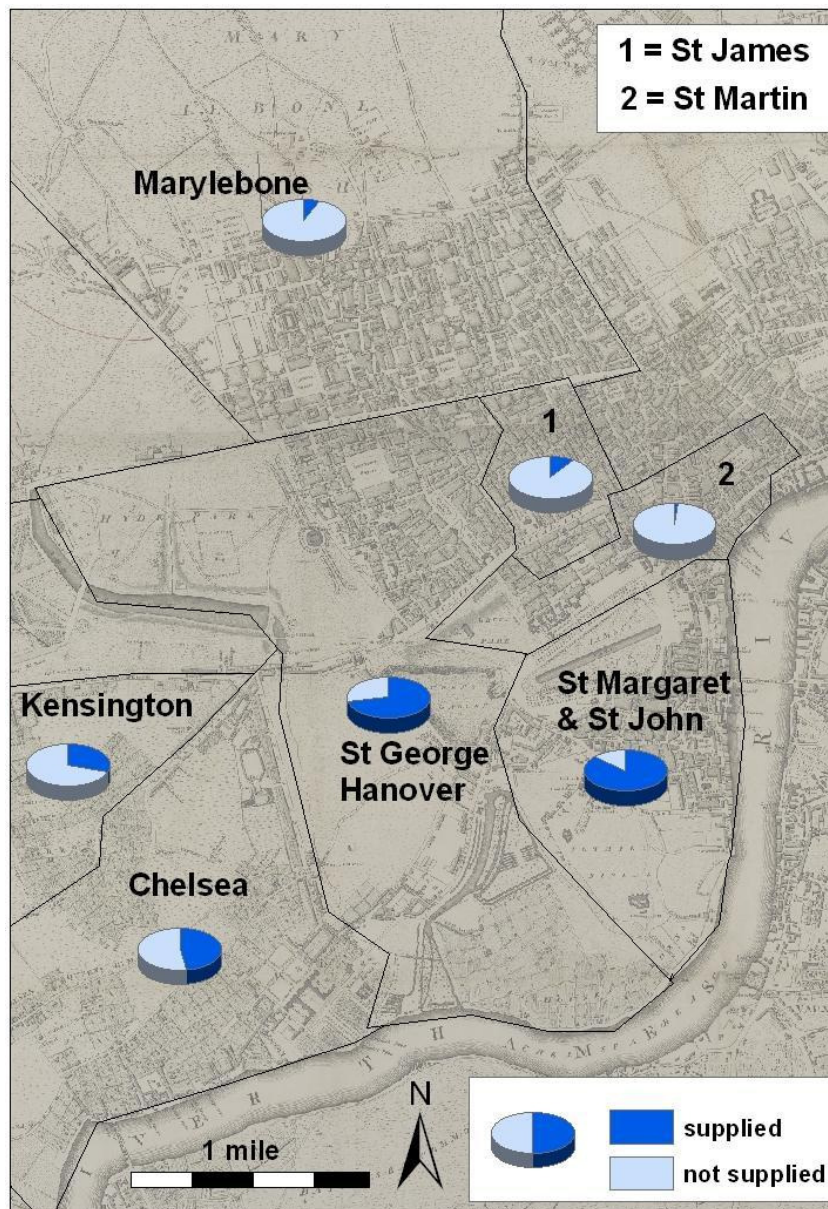
Table 6. 3. Buildings supplied by Chelsea Waterworks in 1804.

Parish	Dwelling houses supplied	Estimated number of houses [†]	% supplied
St Margaret and St John	3,021	3,711	81
St George Hanover	3,134	4,416	71
St Luke Chelsea	764	1,873	41
St Mary Kensington	386	1,394	28
St James	398	3,366	12
St Marylebone	564	7,469	8
St Martin in the Fields	63	2,796	2
Total	8,330	25,024	33

[†] Estimated number of houses in 1804 is based on the 1801 census + 3/10ths of the difference between the 1801 and 1811 censuses.

Sources: Select Committee, PP 1821 (706), p. 215; Census enumeration abstracts for Middlesex, PP 1801 (497), pp. 207-16, and PP 1811 (497), pp. 192-9.

Figure 6. 4. Percentage of buildings supplied by Chelsea Waterworks in 1804.



Sources: as table 6.3. Base-map is Stockdale.

While Chelsea Waterworks supplied over one-third of all houses in the area in which it had pipes, its market penetration varied greatly by parish. Those parishes closest to the company's reservoirs, which were St Margaret and St John, and St George Hanover Square, showed the highest percentages of houses taking up Chelsea water. Three-quarters of the company's customers could be found in these parishes and the company supplied over 70

per cent of all houses there. Lower percentages occurred in parishes farther away, such as Marylebone, which was mainly supplied by the New River Company at the time, and St Martin-in-the-Fields, which it shared with both the New River Company as well as York Buildings Waterworks. While in Chelsea and Kensington Chelsea Waterworks was the only commercial water supplier at this time, the lower percentages there are explained by the fact that these parishes were quite large, and the network had yet to extend across the entire locality.

The market penetration of St Margaret and St John parish (81 per cent) shows the large proportion of people purchasing commercial water there. It is very likely that a similar percentage would have received a commercial supply in St George Hanover Square, as the New River Company supplied there as well (compare figures 6.3 and 6.4). Based on the New River Company's 1769 customer numbers, there were another 831 tenants supplied in this parish (660 from the Marylebone district, and 171 from the Pall Mall district). Assuming that this level of supply stayed constant in the intervening 35 years — it is more likely to have gone up — a total of 3,965 houses were supplied in St George Hanover Square by Chelsea Waterworks and the New River Company combined, meaning that almost 90 per cent of houses in this area received a commercial water supply.⁸³

Written accounts corroborate the extent to which London was supplied with commercially sourced water. An anonymous author in the *Gazetteer and New Daily Advertiser* in 1772 emphasised the spread of the supply, claiming that there was “no part of Westminster and its liberties, but is, or can be served by the Chelsea Water-works, or the

⁸³ Unfortunately, a similar analysis for the Marylebone, St James, and St Martin parishes is unreliable as a result of the expansion of buildings in Marylebone between 1769 and 1804 and the presence of York Buildings Waterworks in the St James and St Martin parishes.

York-building Water-works, or the New-river Company.”⁸⁴ The City of London was described to be “well supplied” by the New River Company and London Bridge Waterworks, “which together serve the city, and as far Eastward beyond the liberties thereof, as (...) the London-hospital, in Whitechapel road.”⁸⁵ The houses east of this road “are or may be well supplied with water” by West Ham Waterworks, while Shadwell Waterworks supplied “from Limehouse-bridge in the East, through Ratcliff, Shadwell, Wapping, Hermitage, Ratcliff-highway, East Smithfield, and Rosemary-lane.”⁸⁶ Tobias Smolett’s 1771 novel *The Expedition of Humphry Clinker* also mentions the city’s commercial water supply, although its main character, Matthew Bramble, was not very complimentary of the quality of the water, describing the New River Company’s supply as “maukish”, and Thames water as “impregnated with all the filth of London and Westminster”.⁸⁷

Contemporary travel writers also pointed out how well the city was supplied with water. As early as 1726 the Swiss visitor César de Saussure was shocked by the amount of water supplied and used by London households, although he expressed surprise that not many people, including the poor, drank it.⁸⁸ Two separate visitor accounts around 1770 mentioned that “all the houses in London” were supplied with water from either the Thames or the New River.⁸⁹ In similar fashion, J.W. von Archenholz wrote in 1797 that “every house in that immense city” was provided with water.⁹⁰ While evidently not every single house was supplied with water, it seems that the more affluent houses, which these visitors were more likely to frequent, tended to have a commercial water supply.

⁸⁴ Anonymous, letter in *Gazetteer and New Daily Advertiser*, 11 Aug. 1772.

⁸⁵ Ibid.

⁸⁶ Ibid.

⁸⁷ Smolett, T., *The Expedition of Humphry Clinker* (London, 1771), p. 120.

⁸⁸ In Inwood, S., *A history of London* (Basingstoke, Papermac, 2000), p. 282.

⁸⁹ Du Boccage, Mme., *Letters concerning England, Holland, and Italy* (London, 1770), p. 27; Grosley, P.J., *A tour to London: or, new observations on England, and its inhabitants* (Dublin, 1772), pp. 85-6.

⁹⁰ Archenholz, J.W. von, *A picture of England* (London, 1797), p. 295.

South London, meanwhile, was markedly less well supplied. At an internal board meeting, Lambeth Waterworks reported in 1797 that its mains supplied more than 3,000 houses dispersed over two miles in length and one-and-a-half miles in breadth, roughly from Vauxhall to Maiden Lane in Southwark, and between Walworth and Kent Road. According to their estimates, not more than half the houses that the mains passed by were supplied with water.⁹¹ London Bridge Waterworks had another estimated 4,000 customers in Southwark, where the smaller Borough Waterworks supplied as well. Unfortunately there are no further details available for these companies around this time as the 1821 Select Committee did not examine the water companies south of the Thames.

6.4. London's water market: price.

The evidence outlined above, as well as written accounts by visitors to the city, testify that over the course of the eighteenth century London's water market had expanded to supply the majority of houses in the capital. This begs the question of how so many people, including those lower down the economic hierarchy, could afford to purchase piped water. Estimating the prices paid for piped water in London relies on piecing together evidence from a diverse range of sources. However, it appears that the cost remained relatively constant over the course of the eighteenth century. One of the earliest sources available is Edward Hatton's 1708 account of London, in which he reported that the city's various companies supplied at an average annual price of around 20s.⁹² There were variations

⁹¹ LMA/ACC/2558/LA/1/2 Lambeth Waterworks, minutes, 17 Oct. 1797.

⁹² Hatton, E., *A new view of London* (London, 1708), pp. 786, 791.

between the companies: the New River Company was slightly more expensive and sold water at no less than 22s 8d per year, while others, such as Millbank Waterworks, supplied customers from 10s and upwards.⁹³ A century later, prices had risen only slightly: figures for 1804 suggest an average of 23s for New River customers, while Chelsea Waterworks' water cost on average 24s per year for domestic houses.⁹⁴ Rates in east London were cheaper at an average 18s per year.⁹⁵

Often, accounts of London's water market have mainly been concerned with the average price a company charged.⁹⁶ However, prices varied considerably and therefore averages can be misleading. Generally, the water-rent was not determined by usage but was calculated as a fixed rate, which was largely a pragmatic response to the fact that the companies had no way of monitoring the flow of water other than the amount of time the mains were switched on. Charges were therefore based on an estimation of water usage, which depended on the size of a house as well as the water-consuming activities that took place in a building, including trades, water closets, fountains, and watering of animals.

The highest paying customers were all industrial users. Table 6.4 shows all customers who paid over £30 a year to the New River Company in 1769, and of those that could be identified, all but one were the owners of breweries. There were only a few of these high-charge payers, but as a group they significantly affected the overall average water price. Figure 6.5 shows a Lorenz curve based on all the New River Company's customers in 1769. This curve is sharply skewed at the upper end, which represents this small group of customers that contributed disproportionately to the company's income from water-rents.

⁹³ Hatton, *London*, p. 792.

⁹⁴ *Select committee*, PP 1821 (706), pp., 206-7, 215, 225.

⁹⁵ *Ibid.*, pp. 227-8.

⁹⁶ E.g. Graham-Leigh, J., *London's water wars: the competition for London's water supply in the nineteenth century* (London, Francis Boutle, 2000).

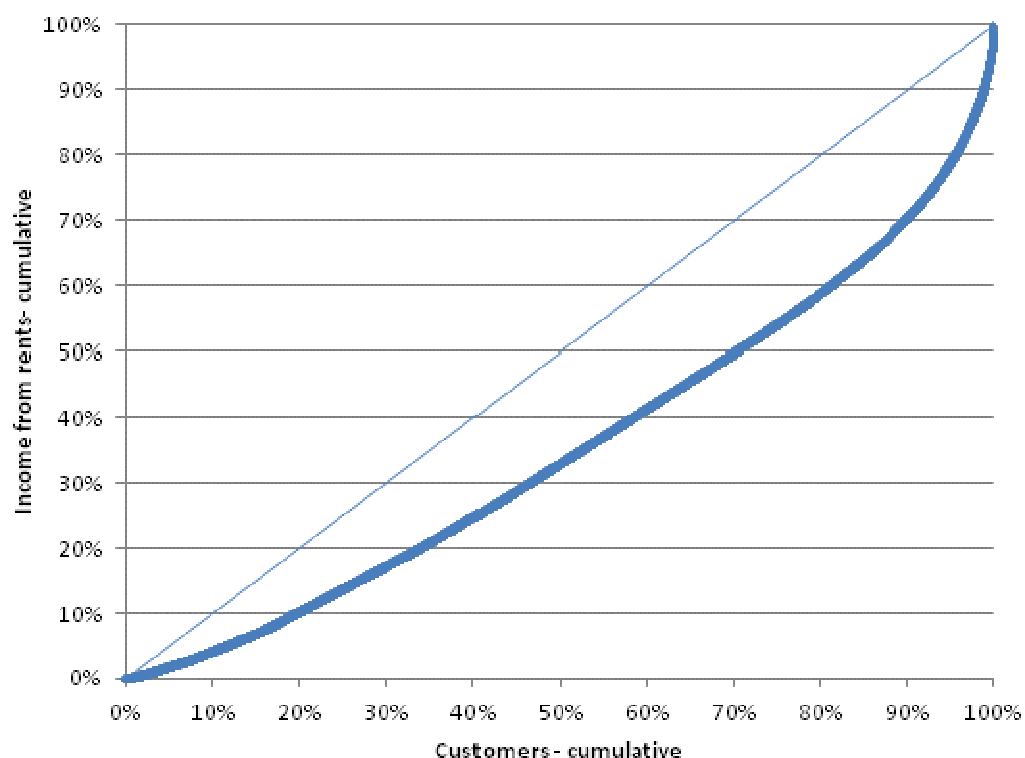
Twenty per cent of the New River Company's water-rent income that year was generated by only five per cent of customers — most of whom were probably industrial users.

Table 6. 4. Highest-paying customers of the New River Company in 1769.

Annual water-rent in £	District	Street	Customer	Business
90	Maiden Lane	Castle Street	Gyfford & Co	Brewer
84	Moorgate 1	Chiswell	Samuel Whitbread	Brewer
84	Whitechapel	Brick Lane	Truman & Baker	Brewer
80	Moorgate	Red Cross	Calvert & Co	Brewer
55	Drake Street	Hyde Street	Robert Hucks	Brewer
38	Red Lyon	St John Street	Wilks & Raw	Not known
38	Spitalfields	White Lyon Street	Thornton	Brewer
37	Red Lyon	Smithsfield	St Bart's Hospital	Hospital
35	Moorgate 2	Old Street	Cokar & Co	Brewer
32	Maiden Lane	St Giles	Mason & Co	Not known
30	Moorgate 2	Golden Lane	Dickinson & Co	Brewer
30	Red Lyon	Long Lane	Sam Hawkins	Brewer
30	Red Lyon	St John Street	Dickinson	Brewer
30	Whitechapel	Nightingale	Allen & Ambrose	Brewer

Source: New River Company, 1769 rent book, LMA/ACC/2558/NR/12/1.

Figure 6. 5. Lorenz curve for New River Company's 1769 income from water-rents.



Source: New River Company, 1769 rent book, LMA/ACC/2558/NR/12/1.

A similar income structure can be found for the other companies. Chelsea Waterworks provided the 1821 Select Committee with its 1804 income breakdown in three categories of customers: domestic, public buildings and trades/manufacturing. Assuming that ‘dwelling houses’ equalled domestic water and ‘other buildings’ included both the public buildings and industries, table 6.5 shows that 94 buildings, which constituted only one per cent of their total customers, provided eleven per cent of Chelsea Waterworks’ income from water-rents that year.⁹⁷ The evidence therefore suggests that a company’s overall average charge overestimates what most domestic customers would have paid.

Table 6. 5. Chelsea Waterworks' income and customer breakdown, 1804.

Income from	£	% of income		Customers	% all customers
Domestic water	10,028	89		8,330 dwelling houses	99
Public buildings	908	8	}11	94 other buildings	1
Trades/manufacturers	284	3			
Total	1,192	100		8,424	100

Source: Select Committee, PP 1821 (706), pp. 215, 220.

Given these differences, how were domestic prices calculated? Chelsea Waterworks initially based its water price on the amount of the poor-rate, but also stated that it was open to negotiation.⁹⁸ By 1810 the company had a systematic price plan for several classes of houses: the cheapest class was houses (“or sheds”) with one to three rooms, which were charged 8s (for one room) to 12s (three rooms) per year.⁹⁹ Larger houses were based on surface area. The second class of houses for example, which contained those which had 250 to 400 superficial feet, were charged at ¾d per square foot. Ten per cent was added or deducted if the house was more or less than three storeys, or, intriguingly, in a “good or

⁹⁷ Chelsea Waterworks’ large customers included the Palaces and Westminster Abbey.

⁹⁸ LMA/ACC/2558/CH/1/2 Chelsea Waterworks, minutes, 8 March and 30 May 1728.

⁹⁹ *Select committee*, PP 1821 (706), p. 48.

inferior neighbourhood". If the customer needed water for their garden another 2s to 5s were added to the price.¹⁰⁰ The larger the house, the higher was the water-rent: the eighth class of houses, which were those with a ground plan of over 1,900 square feet, were charged 1d per square foot. Extras, such as coach-houses or stables, came at an additional 8s to 12s a year.¹⁰¹ The other companies probably had similar pricing structures; while such detailed information is not available for the New River Company, this company's engineer testified in 1821 that their rates were generally calculated based on the size of the house.¹⁰²

The variety of factors involved in determining the annual price — rooms, surface, storeys, neighbourhood, extras — resulted in a huge variety of prices, even within the same street. A breakdown of Chelsea Waterworks' rents from 1804, and New River Company rents from 1769, as shown in table 6.6, demonstrates how diverse the price and therefore the customer base really was.¹⁰³ While the largest category of customers of both companies paid between 20 and 29s, there were also significant numbers that paid less. Indeed, ten per cent of Chelsea's customers paid 10s or less a year, which, based on the 1810 classification, means that they lived in small houses with one or two rooms. The New River Company also had customers paying only 8s or even 6s a year, mostly in the poorer collection districts of Spitalfields and Whitechapel.

¹⁰⁰ *Select committee*, PP 1821 (706), p. 48.

¹⁰¹ *Ibid.*, p. 49.

¹⁰² *Ibid.*, p. 5.

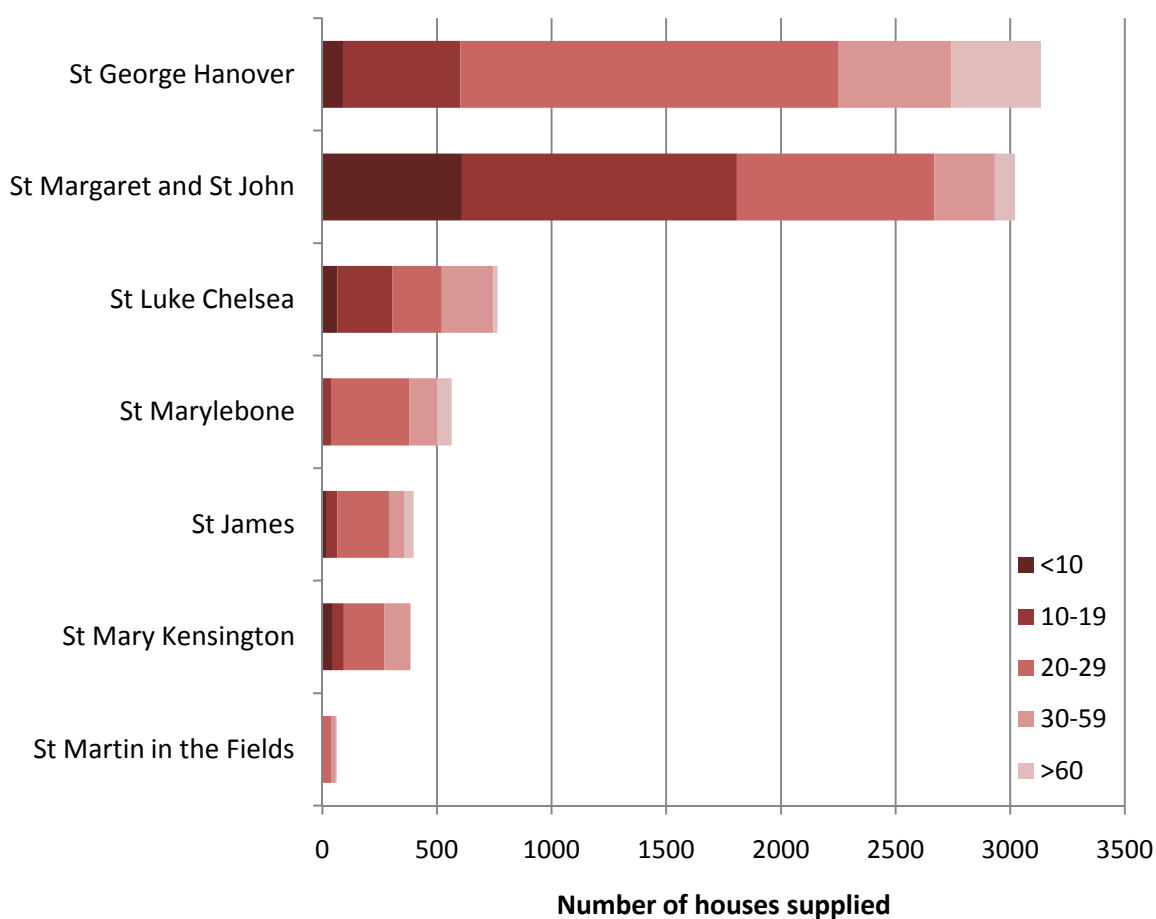
¹⁰³ A similar picture emerges for London Bridge Waterworks' customers in 1821, which showed a clear north-south divide. In that year, 69% of London Bridge customers south of the Thames were supplied for an annual charge of 20s or less, as opposed to 25% of those north of the river. In the City of London the majority (73%) paid between 20s to 50s a year, which was only paid by 30% of customers in Southwark. *Select committee*, PP 1821 (706), p. 202.

Table 6. 6. Price breakdown for Chelsea Waterworks (1804) and New River Company (1769).

	New River Company 1769		Chelsea Waterworks 1804	
Annual rent (shilling/year)	N	%	N	%
<10	156	1	832	10
10-19	4,145	16	2,082	25
20-29	16,493	63	3,507	42
30-59	3,818	14	1,299	16
>60	1,585	6	610	7
Total	26,197	100	8,330	100

N = number of tenants (New River Company) or houses (Chelsea Waterworks), % = percentage of total. Source: Select Committee, PP 1821 (706), p. 215; New River Company, 1769 rent book, LMA/ACC/2558/NR/12/1.

Figure 6. 6. Chelsea Waterworks' 1804 water-rents for dwelling houses, breakdown by parish, in shilling per year.



Source: Select Committee, PP 1821 (706), p. 215.

Figure 6.6 shows a water-rent breakdown by parish for Chelsea Waterworks' 1804 customers. Focusing on the parishes with the highest supply, the difference in price structure is striking. The parish of St George Hanover Square contained almost 400 customers who paid over 60s for their water. This area formed part of the wealthy West End and contained some of the most expensive houses in town at this time, with those on St James Square costing between £200-350 to rent annually.¹⁰⁴ The parishes of St Margaret and St John on the other hand, a poorer area with lower quality housing, included many more houses with cheap rents.¹⁰⁵ Over half the people paying for water in these parishes paid less than 20s per year, with 608 people paying less than 10s.

Variations like these occurred across the capital, and the New River Company's 1769 water-rent book allows for a London-wide analysis of water prices.¹⁰⁶ Table 6.7 shows the difference tenants paid in east London (based on the Spitalfields and Whitechapel collection districts) and in west London (based on Marylebone and Berwick). Almost half of the company's customers in the eastern collections districts paid less than 20s, as opposed to only seven per cent in west London. Tenants in the western districts fell mostly in the 20s to 60s range. But these numbers do not tell the whole story, as they represent what the company received from its tenants, rather than what was charged per house. As rents in east London were often farmed out, some of the more expensive rents paid in the east would have been subdivided in cheaper rents for the actual users of the water, meaning that, in reality, the number of people paying less than 20s would have been larger.

In addition to the larger number of cheap water-rents, the east London districts also showed a larger proportion of the most expensive rents: over 60s a year. This is a result of a

¹⁰⁴ Rudé, G., *Hanoverian London, 1714-1808* (London, Secker and Warburg, 1971), pp. 45-6.

¹⁰⁵ Guillery, P., *The small house in eighteenth-century London* (New Haven, Yale University Press, 2004), p. 26.

¹⁰⁶ LMA/ACC/2558/NR/12/1 New River Company, rent book, 1769.

greater number of industrial water consumers in this area, such as the Truman Brewery, which paid £84 a year. These high-rent payers skewed the average charge so much that while the average water-rent in both areas was 29s, in the eastern districts the median rent was 20s, while in the western ones it was 24s.

Table 6. 7. Breakdown of the New River Company's prices in the west and east, in shilling per year, 1769.

Shilling/year	West		East	
	N	%	N	%
< 10	7	0	70	2
10-19	292	7	1,491	43
20-29	2,698	63	1,149	34
30-59	1,020	24	417	12
>60	263	6	314	9
Total	4,280	100	3,441	100

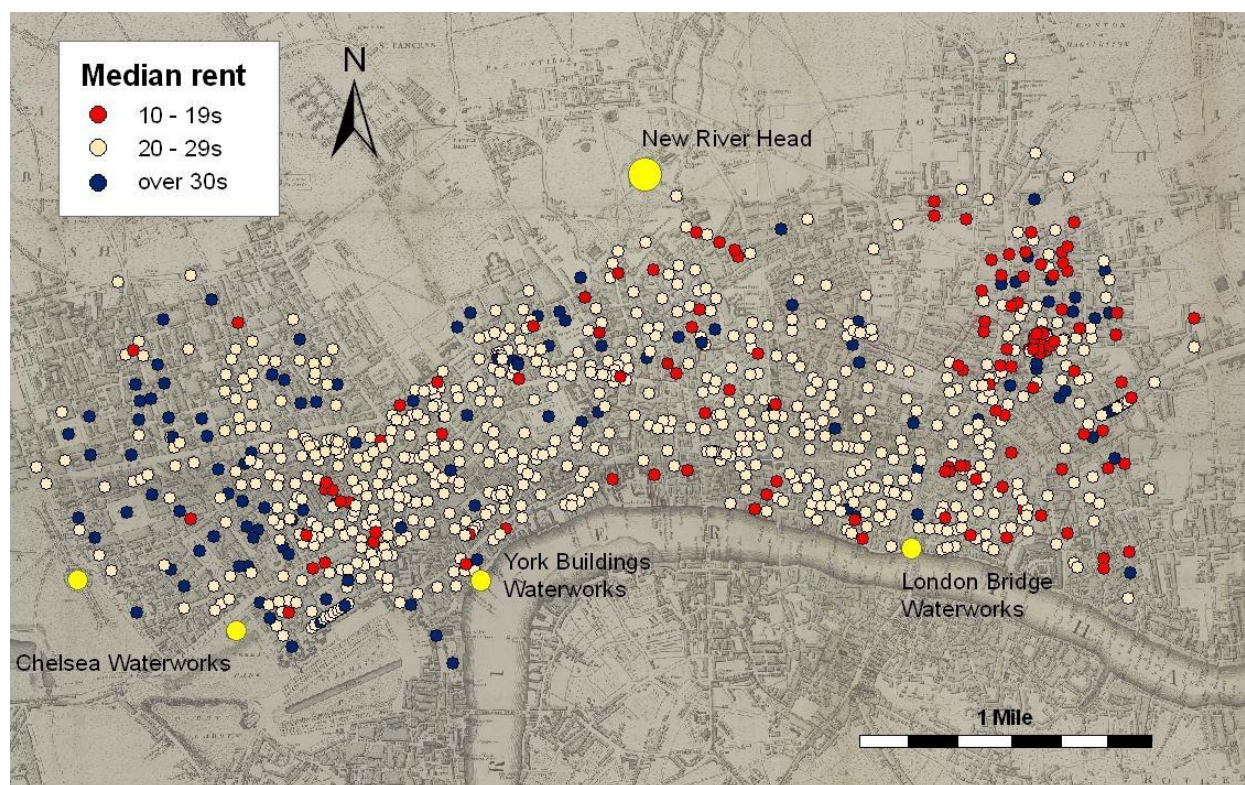
N = number of tenants, % = percentage of total. West is based on Marylebone and Berwick Street collection districts. East is based on Spitalfields and Whitechapel collection districts. Source: New River Company, 1769 rent book, LMA/ACC/2558/NR/12/1.

As a result of this variation in rents, using the median rather than the average water-rent provides a better picture of the geography of the New River Company's water pricing in the city. Figure 6.7 shows the median annual price people paid by street in three tiers: 10-19s, 20-29s, and over 30s per year. The overall median rent for the whole company was 24s, and most streets throughout London fell in the 20-29s range. Higher median annual rents occurred mainly in the West End and Bloomsbury area, while cheaper water, for less than 20s a year, could mainly be found in the east, suggesting a correlation between water prices and the overall prosperity of the area.¹⁰⁷ There were notable exceptions to this: a

¹⁰⁷ For comparison, see the map on page 108 of Spence, C., *London in the 1690s, a social atlas* (London, Institute of Historical Research, 2000); or Schwarz, L., 'Social class and social geography: the middle classes in

concentration of higher rents near Spitalfields reflects a mixture of the remaining Huguenot weavers, industrial customers, as well as builders who paid for a large number of houses and farmed them out. Streets with cheap rents could also be found dotted throughout the West End. These were often yards, passages, or courts located off the squares and stately streets. The dependency of West End's wealthier inhabitants on an army of labourers, servants, grooms, washerwomen, and craftsmen was so great that even in the most fashionable neighbourhoods there were buildings designed for the 'lower classes', with mews developed to keep these people close but out of sight.¹⁰⁸

Figure 6. 7. New River Company median water price by street, 1769.



Source: New River Company, 1769 rent book, LMA/ACC/2558/NR/12/1. Base-map is Stockdale.

London at the end of the eighteenth century', in P. Borsay, ed., *The eighteenth-century town: a reader in English urban history, 1688-1820* (London, Longman, 1990), pp. 315-337, pp. 322-3, 326.

¹⁰⁸ Inwood, *History of London*, p. 263.

Figure 6.7 shows that the water-rent distribution was predominantly decided on house price: richer areas had higher median rents, and the poorer areas lower. While at the 1821 Select Committee hearings the officials of several companies stated that the price was partly based on the length of pipes and level of the ground — which means, essentially, the cost of supplying — it was also noted that this was applied very haphazardly.¹⁰⁹ This is brought out by the evidence: figure 6.7 shows areas nearest to the New River Head with average rather than low prices, while areas where some of the cheapest prices could be found were at a similar distance to some of the highest ones on the other side of town. Most importantly, proximity to other waterworks did not lower the price either. In fact, some of the areas where the highest prices were charged were also covered by Chelsea and York Buildings Waterworks, and the water-rents in the collection district of Leadenhall, which covered the City and thus the main area that London Bridge Waterworks supplied, were similar as to those around Clerkenwell, where the New River Company was the only supplier. This lack of variation in price where other suppliers were present is indicative of a market oligopoly, in which prices could be set at a higher level than it could have been if the companies competed. The pricing structure, therefore, was determined less by market forces than by the combinations made by the companies in order to reduce competition.

The proportion of people supplied with water, as well as the spread in prices, makes it clear that piped water was not just a luxury for the wealthy, but was also provided for other, less affluent groups in the city. The people of St Margaret and St John who were supplied by Chelsea Waterworks for 10s a year lived in one- or two-room houses. Even the slightly more expensive rents were for houses measuring 250 to 400 square feet, which would have

¹⁰⁹ *Select committee*, PP 1821 (706), pp. 21-2.

equalled the living space for an artisan family.¹¹⁰ This was the area that *Curtius* referred to as he expressed his concerns for the poor whose bellies could not be spared to buy water.

6.5. New entrants and support for competition.

The way in which prices were determined, and the market was organised, was a pertinent topic especially because of this broad segment of the population that mainly depended on the companies for their supply. The proposed solutions that customers could turn to in order to break the power of the companies and provide a cheaper supply for the poor differed. *Aquae Vindex* favoured a public, municipal supply, so that water would be freely available to be fetched, leaving the companies to supply only those who desired the additional luxury of having it conveyed to their houses.¹¹¹ This would solve the problem of the lack of alternative sources that forced the poor to buy their supply from the companies. *Curtius* and John Robins, on the other hand, sought a solution from within the market: both aimed to break the companies' monopolistic power by having multiple competing water companies supply the city. John Robins called on wealthy people to make the investment in a new water company, which would break east London's spatial monopoly after the Shadwell/West Ham agreement, while *Curtius* wished "there were twenty more water-works, and that all by a reasonable charge might prosper."¹¹²

This preference for a competitive market for water was more widely expressed when there was the possibility of an additional company, such as during the time of the Colne

¹¹⁰ Guillery, *Small house*, pp. 49-50.

¹¹¹ *Aquae Vindex*, letter in *Morning Post and Daily Advertiser*, 14 Dec. 1775.

¹¹² Robins, *Bone to pick*, pp. 66-7, 92; *Curtius*, letter in *Morning Post and Daily Advertiser*, 15 Dec. 1775.

proposals. When this potential company was being promoted and discussed in Parliament in late 1766 and early 1767, several letters appeared in the public press promoting the plans for a new company in order to prevent “a monopoly of a most valuable element” in the West End.¹¹³ The identity of those who wrote the letters is unclear — all wrote under a pseudonym — and it is feasible that they might have had a financial interest in this venture rather than merely expressing concerns about an unfair market structure.¹¹⁴ Still, through their discourse the public came to be educated and informed about the way London’s water market operated, and how competition would make a difference. For instance, an author who signed his letter ‘D.L.’ explained to the readers the difference in price a competitive rather than a monopolistic market structure would mean:

“When we have but one shop to go to, we must take the commodity at the seller’s own price; and in many parts of Westminster, where the water is alone supplied from the New River, individuals have suffered great inconveniences. But it is to be hoped the parliament will, by opening fresh shops, prevent an almost absolute monopoly.”¹¹⁵

These sentiments were echoed by ‘*An Anti-Monopolist*’, whose letter was published on 27 February 1767.¹¹⁶ He also described the New River Company as the only shop for many parts of the West End, and the Colne company would be another shop, which would “prevent a monopoly in such places.”¹¹⁷

But price was not the only reason why “it is in the interest of this metropolis to oppose every growing monopoly of one of the most valuable and necessary articles of life,

¹¹³ Words used by L.S., letter in *Gazetteer and New Daily Advertiser*, 10 Feb. 1767.

¹¹⁴ However, none of the initials of the authors matched any of the known Colne investors.

¹¹⁵ D.L., letter in *Gazetteer and New Daily Advertiser*, 23 Feb. 1767.

¹¹⁶ *An anti-monopolist*, letter in *Gazetteer and New Daily Advertiser*, 27 Feb. 1767.

¹¹⁷ Ibid.

*Water.*¹¹⁸ Someone opposed to the establishing of the new Colne company had, at a meeting to notify the public about the plans, interrupted to inform the people there that the New River Company was capable of supplying the West End on its own, and had called on a “respectable engineer” present to “confirm the abundance they have always had in that river”.¹¹⁹ While D.L., in his letter, disputed this fact, he wrote that even if the New River Company would have been able to supply the West End on its own, the “inclination of distributing a sufficient quantity, may, perhaps, be doubted.”¹²⁰

What D.L. pointed out here, was that a company in a monopolist position did not have the incentive to produce at maximum demand, as scarcity would tend to keep the price high (this is the deadweight loss as represented in figure 6.2 by triangle EFC). In this context, D.L. compared the New River Company with the Dutch East India Company, which destroyed a part of their spices so that the remainder could be sold at a higher price. Similarly, D.L. wrote, it was not in the New River Company’s interest to supply as plentiful an amount of water as it was able to for precisely the same reason. If the company limited the amount it distributed, it could demand a higher price.¹²¹ The same comparison was drawn 14 years later on the other side of town by John Robins, who compared Shadwell Waterworks’ monopoly to that of the Dutch over eastern spices.¹²² Another reason presented to the reading public about the need to break the monopoly therefore was that additional companies would not only charge a lower price, but also result in a more plentiful supply for the metropolis.

¹¹⁸ Cursive in original, D.L., letter in *Gazetteer and New Daily Advertiser*, 23 Feb. 1767.

¹¹⁹ Ibid. This engineer was probably either Smeaton or Yeoman, as both had been present at similar meetings answering questions from the public for the Colne proposals and both also would have had knowledge of the New River Company’s circumstances.

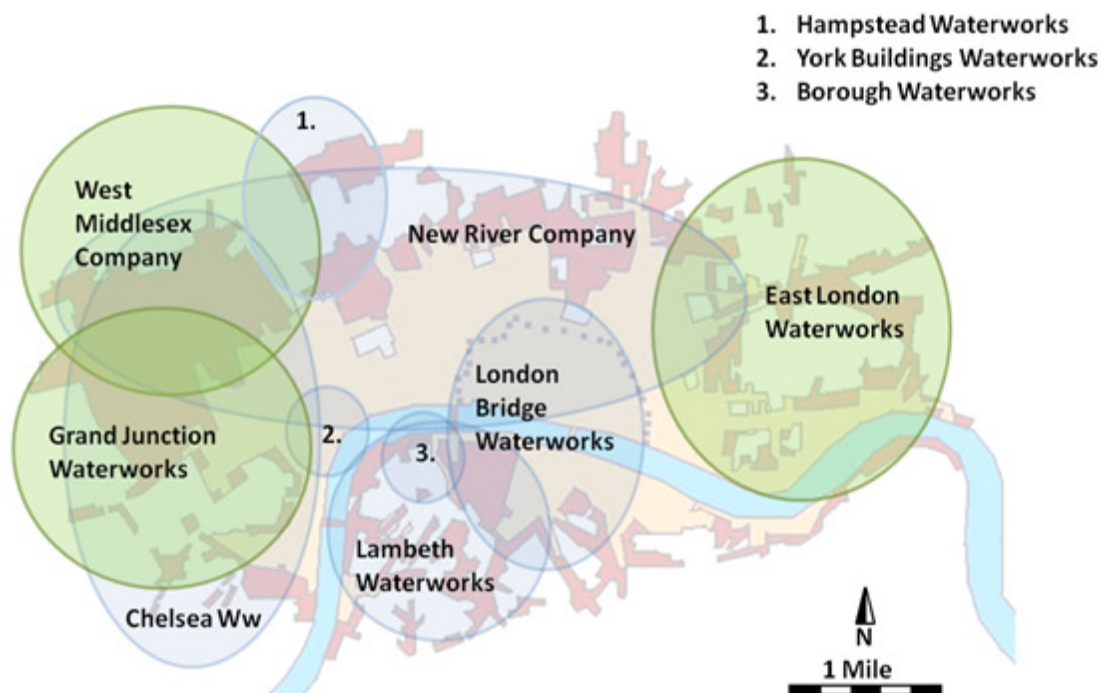
¹²⁰ D.L., letter in *Gazetteer and New Daily Advertiser*, 23 Feb. 1767.

¹²¹ Ibid.

¹²² Robins, *Bone to pick*, p. 71.

While the plans to establish a Colne company, as discussed, never made it through Parliament, in the early 1800s proposals for several new companies were successful, initiating a period of fierce competition in the water industry. In the east of London, East London Waterworks (est. 1807) took over West Ham and Shadwell Waterworks, before eventually constructing its own reservoirs and infrastructure.¹²³ In the West End, two new companies, the West Middlesex Company (est. 1806) and Grand Junction Waterworks (est. 1811) were set up to supply new neighbourhoods that had as yet no water supply, but eventually encroached on the territory of the incumbent companies.¹²⁴ Figure 6.8 depicts the approximate locations of the new companies, and the areas they contested.

Figure 6. 8. The water companies, c. 1815.



¹²³ These companies had been taken over by the London Dock Company as a result of the construction of the docks in Wapping, which had cut many of the mains and destroyed some customers' houses.

¹²⁴ Graham-Leigh, *London's water wars*, pp. 26-51. There was also South London Waterworks (est. 1805), which supplied south London. As it did not participate in the competition this company has been omitted here.

Again, the supporters of the new companies expressed the desirability of competition and breaking up the existing monopoly. For instance, in 1810 the West Middlesex Company issued a note to the public that attributed the current high price people paid for water as a result of the old companies failing to keep up with the rising demand for water in the expanding metropolis. The company's note claimed:

"It is doubtless on this account that parliament has of late thought fit to incorporate so many new water companies; by whose competition, as the supply must of course increase, a corresponding diminution could not fail to take place in the price of the commodity."¹²⁵

Indeed, the entry of the new companies had this desired effect: during the short period of intense competition that followed, especially over the expanding West End market, water charges dropped significantly.

The new companies attracted customers with their lower prices, and also with promises of a constant rather than intermittent supply. In order to prevent losing their market share, the old companies were forced to drop their prices.¹²⁶ This is evident from the data shown in figure 6.9, which compares the prices that Chelsea Waterworks and its direct competitor Grand Junction Waterworks charged during this time. Between 1809 (when only Chelsea supplied) and 1814 (when both companies competed) Chelsea Waterworks' charges went down as a result of Grand Junction's entry.¹²⁷ While the company still gained almost 400 customers in this period (possibly before competition started) changes between water-rent

¹²⁵ Written in 1810, *Select committee*, PP 1821 (706), p. 75.

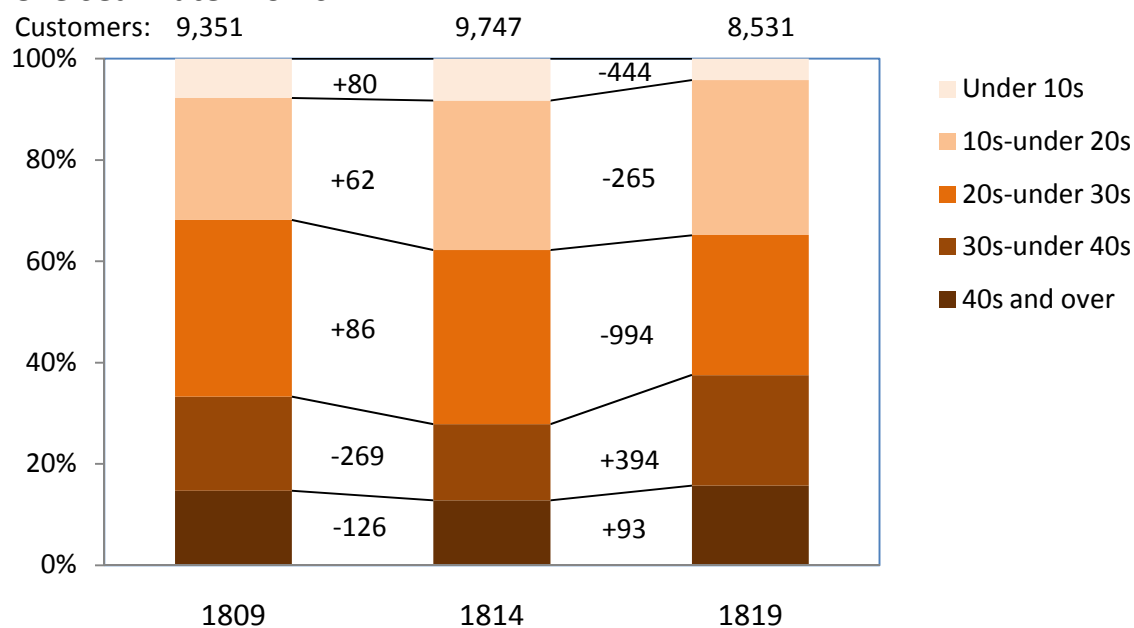
¹²⁶ They also were pushed to improve their supply and switched to using iron infrastructure. Hillier, J.O., 'Constructing London's water supply: a study of engineering and modernity' (PhD Thesis, University College London, 2009).

¹²⁷ The Grand Junction Company also offered a more frequent supply than Chelsea Waterworks, which was another reason to switch supply.

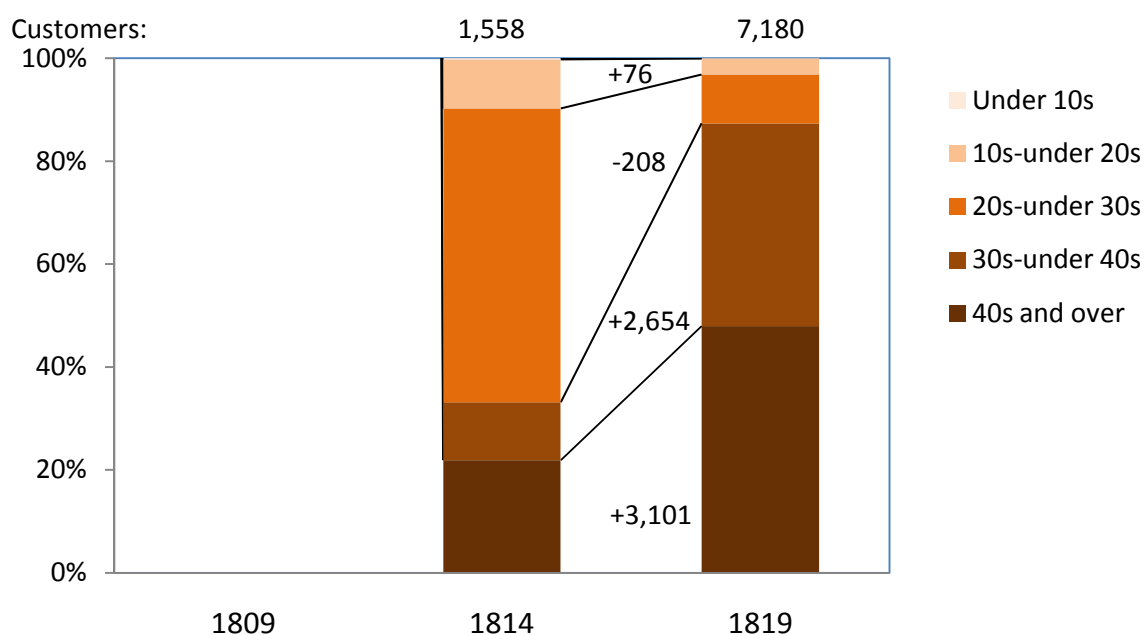
bands indicate a movement towards cheaper rents: the more expensive bands of '40s and over' and '30s-40s' lost customers, while the cheapest bands 'under 10s' and '10s-20s' together contained over 700 more customers by 1814.

Figure 6. 9. The effects of competition on Chelsea and Grand Junction Waterworks.

Chelsea Waterworks



Grand Junction Waterworks



Source: Select Committee, PP 1821 (706), pp. 215-8, 239-40.

As we have already seen, in an oligopolistic situation, any attempt by new companies to reduce the price of water was unlikely to be sustained since it was neither necessary to do so once the new companies had gained a market share nor advantageous for the companies themselves in the long run. Between 1815 and 1818, new non-competition agreements were made between all companies, in which the capital was divided into districts, each to be supplied by one company.¹²⁸ This meant that, effectively, all companies (except London Bridge Waterworks and the New River Company in the City) had their own spatial monopolies and, as a result, they could raise their prices. As evidenced by the data shown in figure 6.9, between 1814 (competition) and 1819 (new agreements) Chelsea Waterworks had raised its prices to slightly higher levels than before the competition started, while Grand Junction Waterworks' charges even exceeded those of its former rival.

The price rises following the new arrangements of the late 1810s sparked new protests against the way the companies controlled the market structure of London's water supply. In various parishes consumers grouped together to agitate for lower charges for their supply. The most visible group was in the parish of Marylebone, which was one of the most contested areas during the period of competition and which had benefited from much lower prices during this time. In 1819 the Anti-Water Monopoly Association was established there by James Weale, which was an organised attempt to resist the price rise, and to continue paying the lower prices at competition level.¹²⁹ Like John Robins had experienced earlier, this practice was not very successful: in a monopolistic market structure the companies had the power to either force people to pay or cut their water off as they had no other company to go to. As a result, the Anti-Water Monopoly Association moved to challenge the market

¹²⁸ Graham-Leigh, *London's water wars*, p. 52-61.

¹²⁹ *Ibid.*, p. 72-3.

structure, first through court actions, and then by instigating the Parliamentary enquiry into the supply of water.¹³⁰

Weale's main claim was that the companies had raised the price in order to enrich themselves. He argued for charges that were no higher than necessary to reimburse the cost of supply, so water would be available cheaply for the poor.¹³¹ The discussion, that Weale ignited and that the Select Committee aimed to address, is essentially represented by the square DEBF of figure 6.2, and represents the profits a company made from raising the price from a competition price to a monopoly (or oligopoly) price. This is illustrated by the evidence of one of the witnesses Weale called up for the Select Committee: Thomas Hope, of Upper Seymour Street in Marylebone, had allegedly asked his Grand Junction collector on which grounds his water-rent had been raised. The reply he received was that the company could not afford to supply for less money, and while the old rent covered the waterworks, paid the salary of employees, and the whole expense of the establishment, "if the proprietors do not get something more, to enable them to share a satisfactory dividend, they would not be content".¹³² Hope concluded from this that the Grand Junction Company merely wanted to raise the rents in order to increase their profits.

The water companies denied that the higher charges were solely for their own benefit, and defended their raising of the prices on the grounds that these reflected the improvements in water supply made during the first decades of the nineteenth century. It was claimed by the old and the new companies alike that more water was being supplied, the reliability of services had increased, and some of the mains were kept full of water at all

¹³⁰ Graham-Leigh, *London's water wars*, pp. 72, 75.

¹³¹ *Select committee*, PP 1821 (706), p. 71. As he acknowledged that competition was destructive to all the companies, a municipal supply would be the best alternative, as *Aquae Vindex* had argued as well. He also claimed to share this author's concerns that water should be affordable for the poor, *ibid.*, pp. 71, 81.

¹³² *Ibid.*, p. 132.

times, resulting in a better protection in cases of fire. This had come attached with additional expenses, as it had meant an increase in use of coals, since more water needed to be raised, as well as an investment in infrastructure as the companies moved from wooden to iron pipes.¹³³ In other words, all companies believed that the higher prices reflected the higher costs for a better supply, and not an unfair rise as a result of the market structure to benefit investors in the companies.

Obviously, the expectation of making money was one of the reasons why people invested in the water companies. The profits of the New River Company in particular were taken as an inspiration by those who founded new companies.¹³⁴ Indeed, by the eighteenth century the example of this company had shown that money could be made as a water company shareholder: New River Company shares came attached with a yearly dividend of £265 averaged over the eighteenth century — an income that would place a shareholder in the top three per cent of London's population.¹³⁵

Figure 6.10 shows the evolution of New River Company's dividends from 1633, when the first modest dividend was turned out, to 1823, after the impact of the competition. The company showed a consistent rise in profits, although there were several fluctuations related to investments, periods of expansion, and market influences. The most dramatic and visible of these was the period of competition in the 1810s. The deep impact this had on the

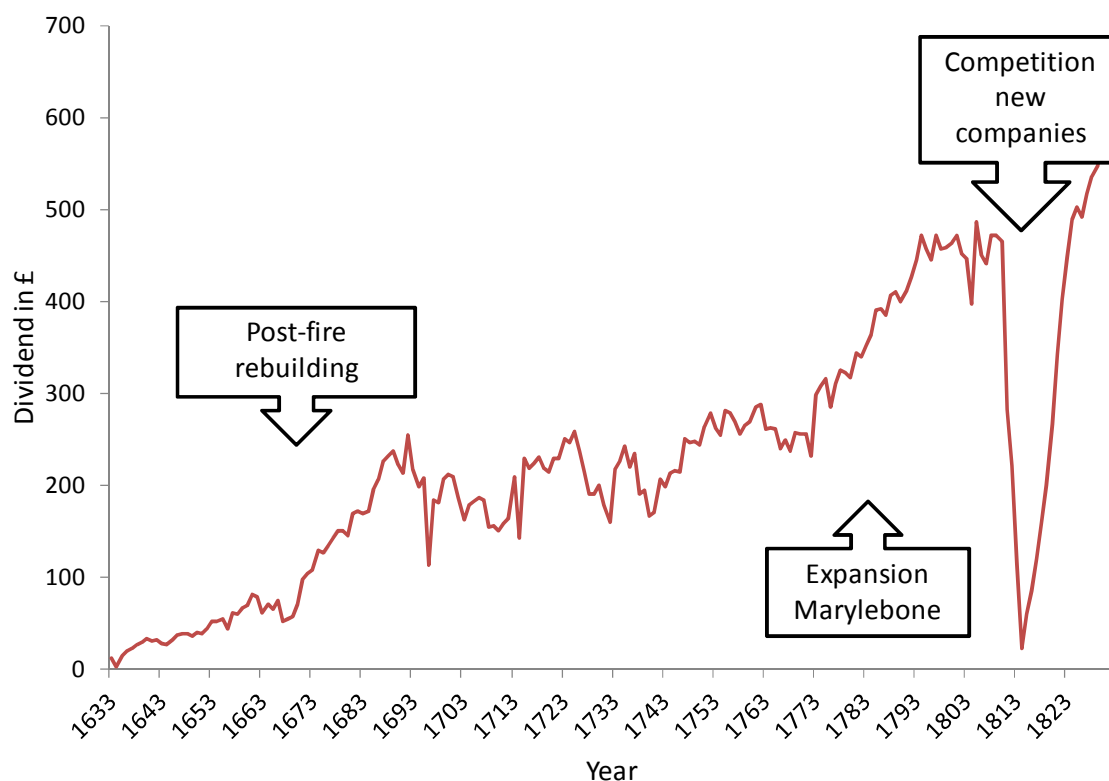
¹³³ For evidence from the New River Company's engineer, *Select committee*, PP 1821 (706), pp. 8, 17; for Chelsea Waterworks' more frequent and abundant supply, *ibid.*, p. 183; the engineer to the Grand Junction Waterworks justification of increased prices, *ibid.*, p. 37.

¹³⁴ E.g. Efford, W., *A Scheme For the Better Supplying this Metropolis With Sweet and Wholesome Water from the River Coln* (London, 1764), p. 8; *Select committee*, PP 1821 (706), p. 174.

¹³⁵ Schwarz, L., *London in the age of industrialisation: entrepreneurs, labour force and living conditions in the capital, 1700-1850* (Cambridge, Cambridge University Press, 1992), p. 57; Rudden, *New River*, appendix.

company's dividends, and the quick recovery once the new agreements were made, confirm that the company normally profited from its monopoly position.¹³⁶

Figure 6. 10. New River Company's dividends.



Source: Rudden (1985), appendix pp. 306-8.

The New River Company tried to downplay their profits in the committee hearings, however, and claimed that the company had not made profits “above six-and-a-quarter per cent, and for many years past not five per cent on their capital”.¹³⁷ These claims seem extremely unlikely considering the steep rise in profits over the century, but the directors apparently were able to get away with it as no-one exactly knew how much the capital of the New River Company was: contemporary estimations ranged from £500,000 to

¹³⁶ The company lost over 4,000 customers between 1809 and 1819. *Select committee*, PP 1821 (706), p. 207.

¹³⁷ *Ibid.*, p. 75.

£900,000.¹³⁸ More recent calculations have put the figure much lower: the original New River Company shares had only cost an initial £100 down-payment, with a commitment to subsequent call-ups, and it has been estimated that the original shareholders never paid more than £289 for their stake in the company.¹³⁹ This meant that a few shareholders had made enormous gains on their investments — at the cost of customers paying inflated charges.

The New River Company was an exception, however, as other waterworks' shares were not as profitable. Chelsea Waterworks, for instance, only started declaring a dividend of eight shillings per share in 1737, fifteen years after its shareholders had first made their investments of £20 a share.¹⁴⁰ The investors only received this income for four years, however, as the company did not make any profits during the 1740s while it focused on investing in their steam engine. From 1754 onwards dividends became more regular and gradually increased over the remainder of the century from six to ten shillings a year per share.¹⁴¹ On an average holding of 25 shares this meant that by the latter half of the century, Chelsea's shareholders earned on average £10 a year from an initial investment of £500, a huge difference from New River Company shareholders who received dividends in the £100s.¹⁴²

London Bridge Waterworks issued similar dividends to its investors. In 1793 ten of its shares were offered for sale, and were advertised as having a £30 annual income

¹³⁸ *Select committee*, PP 1821 (706), pp. 75, 77.

¹³⁹ Ward, *New River*, p. 25; Rudden, *New River*, p. 19. Based on total outgoings at the time the company started making a profit.

¹⁴⁰ Over 4,000 shares, this came to £1,600. LMA/ACC/2558/CH/1/605 Chelsea Waterworks, dividend book, 1737-1760.

¹⁴¹ LMA/ACC/2558/CH/1/605 Chelsea Waterworks, dividend book, 1737-1760.

¹⁴² *Ibid.*

attached.¹⁴³ While its shares had had a nominal value of £100 at the start of the century, from 1789 onwards they were generally traded for £70, and returned a dividend of £2 to £3 per share.¹⁴⁴ These rates were comparable with consols, which also returned three per cent, and provided a much safer investment. Many of the other water companies, including York Buildings, Shadwell, and Lambeth Waterworks, did not return any dividends at all for long periods. While the proprietors of waterworks expected a return on their investments — West Middlesex directors considered their shareholders to be entitled to receive five per cent on their investment, while Chelsea Waterworks claimed theirs were happy with two to three per cent dividends — few of the companies returned profits that were considered a burden on their paying public.¹⁴⁵

This was also the conclusion reached by the 1821 Select Committee.¹⁴⁶ Despite being chaired by William Fremantle, who had been a member of the Anti-Water Monopoly Association, in its conclusions the committee report acknowledged the “peculiar nature” of the water companies’ task and their high capital outlay, which made unrestricted competition unmanageable. In its view, prices were not unreasonably high, and did not unfairly oppress the public.¹⁴⁷ As a West Middlesex Company spokesperson said during the hearings, they had as a new company attacked the old companies for charging high prices, but once in business they came to realise that the old companies were not charging these

¹⁴³ *Morning Post*, 14 Aug. 1793.

¹⁴⁴ Graham-Leigh, *London’s water wars*, p. 10.

¹⁴⁵ *Select committee*, PP 1821 (706), pp. 164, 178.

¹⁴⁶ They seem to have ignored the New River Company’s profits, or did not have enough reliable information available as to why this company was so profitable while charging similar prices as the other companies. Possible reasons for the New River Company’s success can be found in their geographical and therefore infrastructural advantages (for instance, their engineer W.C. Mylne estimated the expense of maintaining the river as £3-4,000 a year, whereas raising water by engines would have been £16,000 a year. *Select committee*, PP 1821 (706), p. 19). Their early appearance on the scene and establishing a market share might also have contributed.

¹⁴⁷ Quoted in Graham-Leigh, *London’s water wars*, p. 80.

prices because of “false practices”, but because they were needed to cover their expenses. With a sense of irony, he felt that now his company had come under similar attacks as it had dealt out ten years previously.¹⁴⁸

6.6. Discussion: public opinion, proliferation, and needs.

Although there were periods of competition in specific parts of the city, customers in large parts of London often had no choice of supplier and were therefore subject to a monopolistic market structure. In this situation, the company could set a price that customers were obliged to pay, and it was this set of arrangements that drew the most adverse commentary. The extent of public opinion, or even readership of news articles at the current time is difficult to ascertain, and for the eighteenth century the press was even more complex.¹⁴⁹ Indications that this was a significant debate can be found in the fact that *Aquae Vindex*’ first letter was cut out of the newspaper by Robert Mylne, the engineer and surveyor of the New River Company, who put it in his scrapbook.¹⁵⁰ This shows a level of interest in this opinion, or at least what the public thought about the company in general. Many of the letters relating to the Colne initiative were responses to letters sent in by readers, which indicates that these had been read, at the very least, and had incited a response.¹⁵¹ This strongly suggests that London’s water market was being discussed in the

¹⁴⁸ *Select committee*, PP 1821 (706), p. 175.

¹⁴⁹ Black, J., *The English press in the eighteenth century* (London, Croom Helm, 1987), p. 105.

¹⁵⁰ LMA/ACC/2558/NR/13/188 New River Company, Robert Mylne’s commonplace book, c. 1766-1816.

¹⁵¹ E.g. ‘O.’, letter in the *Gazetteer and London Daily Advertiser* of 6 Jan. 1763 responds directly to W.E. in the same paper on 28 Dec. 1762.

public realm in relation to structure and price. The fact that the Anti-Water Monopoly Association managed to obtain a public enquiry suggests that it was a topic that affected enough people, or at least those with the right connections, to warrant Parliamentary interest. More likely, however, the reason for so much interest was the fact that so many Londoners were supplied with water on a commercial basis. A well watered city, therefore, had a potentially large audience interested in and willing to seek some form of investigation and redress in Parliament.

Chapter 7. Private companies and public service.

The previous chapter treated the water companies in terms of their core business: providing a domestic and industrial supply in exchange for money. But there were also occasions when the companies supplied their water free of charge, most notably relating to fire fighting and during periods of acute droughts. In these instances, the water companies performed an important public function for which they received no remuneration. Such corporate responsibility from institutions whose prime aim was to make money raises questions about the way in which public goods were provided by private interests. This chapter, therefore, considers the companies, including their management, infrastructure, and public image, through the lens of their role as the providers of a public service, namely the emergency supply of water in times of acute shortage, such as severe frost, or in case of fire. The main question is why, in a market economy, the companies' directors decided to provide their water for free on these occasions.

There are several reasons why a company would seek to give away its goods without remuneration. Firstly, it could do so because it was compelled by law or political pressure. This is the case nowadays: water companies have to allow "any person to take water for extinguishing fires from any of the mains or other pipes on which a fire-hydrant is fixed", for which they are not allowed to charge.¹ Secondly, the companies could have supplied because they felt it was the 'right' thing to do. Whether a result of moral, religious, or charitable reasons, supplying water for free in emergencies like these constituted a contribution to society which they made from a sense of social responsibility.

¹ Water Industry Act 1991, c. 57 (1), 147 (1a).

Thirdly, there could have been an element of self-interest in this contribution. Corporate social responsibility is partly about the publicity arising from performing a public function, and the companies' actions raised their profile in a positive way. The press as it emerged over the eighteenth century created a platform that allowed the companies to try to influence public opinion. Positive publicity about their ability to fight fires free of charge was useful for the companies as it demonstrated their capacity to supply water and the excellence of their networks, and could therefore help to attract customers. But it was also beneficial for the directors, as the publicity established them as 'good' and 'moral' people, caring for the public over their own personal interests. Especially in the light of the negative comments that the water companies elicited — as discussed in the previous chapter — this might have been an image they coveted, both for their company as well as for themselves. An emphasis on public service helped to legitimate the dividends directors earned from supplying water.² The eighteenth-century business world revolved largely around people's reputations, and charitable actions such as supplying free water to those in need could bolster the directors' social status. Finally, the decision to supply could have included an element of material self-interest on the part of the directors, several of whom often lived in the locality served by their company. Improvement of the local area by the supply of water and the safeguarding against fire would benefit the locality in general, but also the directors' houses and properties in particular.

² See e.g. Yamamoto, K., 'Piety, profit and public service in the Financial Revolution', *English Historical Review*, 74 (2011), pp. 806-834, p. 834.

7.1. Fire and ice: the provision of free water in eighteenth-century London.

The most common situation in which the companies provided their water free of charge was to aid fire fighting. Fires were a frequent and destructive occurrence in the early modern town: a gazetteer of urban fires compiled by Jones, Porter, and Turner counted 76 fires that destroyed at least ten houses over the course of the eighteenth century in London.³ To understand the way in which this hazard was managed, we need to go back to the Great Fire of 1666 and its aftermath. This conflagration, which had originated at the house of a Pudding Lane baker, had burned for four days and destroyed 60 per cent of the City of London. While direct fatalities as a result of the fire have always been recorded as very low — contemporary accounts have counted as few as six people — the indirect effects of the destruction of the capital were far-reaching. Over 13,200 buildings went up in flames, including the Royal Exchange, the Guildhall, and many of the City's livery companies.⁴

The fire's location, at the heart of the City, meant that many merchants' houses as well as warehouses full of valuable goods were destroyed. The traditional way of compensating victims, a charitable subscription for the affected, proved inadequate for those ruined in this event.⁵ In order to prevent similar losses in the future, a system of private fire insurance companies was established to mitigate the impact of eventual future fires by reimbursing (part of) personal losses. The first of these companies was founded in 1667 by Nicholas Barbon. His 'insurance office for buildings' was soon joined by other companies and fire

³ Jones, E.L., Porter, S., and Turner, M., *A gazetteer of English urban fire disasters* (Norwich, Historical Geography Research Series, 1984), p. 15. Slightly more fires were recorded for the later decades, mainly the 1760s, 1770s, and 1790s, which could either be a result of the expansion of the city, or an increase in fire hazards as the Industrial Revolution took off.

⁴ Reddaway, T.F., *The rebuilding of London after the Great Fire* (London, Edward Arnold, 1940), p. 26; Porter, S., *The Great Fire of London* (Stroud, Sutton, 2001), p. 54.

⁵ Pearson, R., *Insuring the Industrial Revolution: fire insurance in Great Britain, 1700-1850* (Aldershot, Ashgate, 2004), p. 4.

insurance grew to be widespread by the middle of the eighteenth century. Having one's house insured against fire extended well beyond the upper and middle classes, and it is likely that only a small proportion of the residential capital remained uninsured by the end of the eighteenth century.⁶

In order to minimise the amount of money they had to pay out, the insurance companies had an interest in the prevention of fire and were willing to invest in this. For example, in 1765 all six London fire insurance companies grouped together to share the cost of prosecuting arsonists.⁷ The most significant action they took, however, was the establishment of their own fire brigades. Barbon's was the first company to offer the service of his own group of men who were made available to extinguish fires as an addition to his policies. Its clients were given the addresses of nearby firemen who they were to alert when there was a fire.⁸ Barbon's competitors followed suit, and by the start of the eighteenth century there were several fire insurance companies in London, each with their own team of around 30 men.⁹

These fire brigades had equipment to fight fires, such as fire-hooks (to pull thatch off the roof), squirts, buckets, ladders, and early fire engines. At the site of the fire, the brigade's engines had to be supplied with water. Usually, people formed bucket-chains from the nearest water source and threw it either directly on the fire or into the engine, and where there was water available in sewers and gutters it was shovelled towards the engines as

⁶ Pearson, *Insuring*, p. 74.

⁷ Ibid., p. 71.

⁸ Holloway, S., *Courage High! A history of firefighting in London* (London, HMSO, 1992), p. 28.

⁹ Ibid., pp. 28, 36. While these were not full-time professional firemen — most of them were working as watermen and fire fighting was an occasional job — they had received training in how the equipment worked, and were as a result of the nature of their job used to working under dangerous conditions. Ibid., p. 29.

well.¹⁰ However, the amount of water that could be produced using these methods was limited and the process took time, especially as distances between available sources and the fire increased. Over time therefore, the network of the companies became the main source of emergency water supply, and the engines were either connected via a hose to fireplugs or, alternatively, water was left to pool in the street and people would use buckets to supply the engine. In Hogarth's engraving of a Union Office crew extinguishing a fire in 1762, shown in figure 7.1, both practices are depicted.

Figure 7. 1. Eighteenth-century fire-fighting scene.



Engraving by William Hogarth. Source: © Trustees of the British Museum.

Supplying water at the site of a fire was not just a passive task in which the companies let the insurance crews take water from the pipes. Because the service pipes were empty when

¹⁰ Blackstone, G.V., *A history of the British fire service* (London, Routledge, 1996), pp. 26, 37.

they were not scheduled to supply, providing an emergency water supply required active management on the part of the companies, and incurred considerable expense. Whenever a fire was discovered residents had to report this to their local turncock, whose address was written on the receipts for water supply, and it was his task to actively redirect water towards the location of the fire. Once there was water in the pipes, the fireplugs near the fire had to be drawn in order to supply the engines. Again, a turncock had to be present for this, as they possessed the special key through which means the fireplugs could be opened.

The fire insurance companies' brigades were thus dependent on the water companies' turncocks, and their quick response. When there was no water available on the scene, it was the fire insurance companies that were the ones likely to incur greater losses as a result of the damage that ensued. This was reflected in a gift from the Phoenix Fire Office, which sent three guineas as a Christmas box for the turncocks of the New River Company in 1786. The company, however, returned this money saying they expected their employees to do their duties without such emolument.¹¹

However, the fire insurance companies also held the water companies responsible for the provision of water at the scene of a fire and complained about their management whenever there was a delay in supplying water. In 1785, the Westminster Fire Office complained to the New River Company that it had taken four hours until there was a sufficient water supply at the site of a fire around Compton and Greek Street. According to the directors of the New River Company, however, there *had* been an earlier water supply, as their first turncock on the scene had drawn a plug and provided water within less than a

¹¹ LMA/ACC/2558/NR/1/3 New River Company, minutes, 11 and 25 Jan. 1787. There was a reward paid by the parish for the first turncock on the scene, so they already had a financial incentive to work quickly.

quarter of an hour of the fire being discovered.¹² Unfortunately, a person unacquainted with the company's infrastructure had then drawn additional plugs on the pipes farther down, which meant that the water flowed out on the lower ground and not where it was needed.¹³ In another case in May 1786 there had been complaints that the New River Company's turncock had turned off the water at a fire in Portman Square. It turned out that the problem was in fact that the staff at the New River Head had not realised there was a fire and had switched the mains as per the usual schedule.¹⁴ The turncock therefore had had to go to Islington to get the main to Portman Square switched back on again. In response, in 1792 the New River Company ordered that when any fire was discovered at night, when the mains were generally dry, the night workman was to turn on the main in the general direction of the fire.¹⁵ Both these cases demonstrate the importance of the active involvement of water company employees and the correct management of their infrastructure in the provision of water at fires. This was by no means an easy task and required coordination between employees across the entire network.

Apart from the managerial effort, providing this service also meant a considerable expense by the companies, for which they received no remuneration. In September 1772, an author who called himself '*Hydraulogos*' addressed this issue in a letter in the *Gazetteer*.¹⁶ He considered Shadwell Waterworks as an example of a company that relied solely on a steam engine to raise water. This engine was turned off at ten o'clock every night in order to save on the cost of coals, and was not switched on again until the next morning,

¹² LMA/ACC/2558/NR/1/2 New River Company, minutes, 14 July 1785.

¹³ LMA/ACC/2558/NR/1/3 New River Company, minutes, 21 July 1785

¹⁴ *Ibid.*, 15 June 1786.

¹⁵ LMA/ACC/2558/NR/1/4 New River Company, minutes, 30 Aug. 1792.

¹⁶ This was part of several letters addressing London's fire-fighting apparatus around this time. *Hydraulogos*, letter in *Gazetteer and New Daily Advertiser*, 18 Sep. 1772.

when “the domestic necessities of their tenants oblige them”.¹⁷ *Hydraulogos* recognised that if the engine was kept running constantly to ensure a steady supply of water in case of fire, this would mean “very extraordinary expenses to the Company, without the least means of reimbursements”.¹⁸ Indeed, overrunning the engines without additional payment came at a considerate cost to the owners of Shadwell Waterworks, and, as they reminded the directors of several fire insurance companies in 1794, they covered these costs “selflessly” even though the company was in debt and had not returned any profits for 25 years.¹⁹

Hydraulogos also considered the pipe network of the New River Company, which relied mainly on gravity. While this company would not need to go to the expense of raising extra water, *Hydraulogos* believed that it could not quickly supply a large quantity at the location of a fire “without distressing their [paying customers], which it is their duty not to do”.²⁰ Similarly, *Hydraulogos* believed that while West Ham Waterworks, which relied on a fire engine but also had a reservoir for an immediate supply, was best equipped to provide water quickly, it could not be expected of the company to have a turncock always on stand-by at the reservoir.²¹ In each of these cases *Hydraulogos* drew attention to companies having to go to considerable expense to make water freely available to fight fires, while receiving nothing in return.

Still, the companies showed a willingness to provide an emergency supply in face of these expenses. The directors of Lambeth Waterworks, for instance, intended to construct

¹⁷ *Hydraulogos*, letter in *Gazetteer and New Daily Advertiser*, 18 Sep. 1772.

¹⁸ *Ibid.*

¹⁹ LMA/ACC/3077/12 Shadwell Waterworks, memorial to fire offices, 2 Jan. 1794. Around this time, the company was seeking support against the London Dock Company.

²⁰ *Hydraulogos*, letter in *Gazetteer and New Daily Advertiser*, 18 Sep. 1772.

²¹ *Ibid.*

infrastructure specifically to help in fire fighting by building a reservoir. However, the problem was that this would come at too high an expense for the company's directors, as the reservoir was estimated to cost £2,000, and the company was only just starting up and had a capital of only £3,200.²² In order to raise money, they proposed to open a subscription for local inhabitants, and also contacted the directors of both the Sun Fire and Phoenix Fire Offices, as they were likely to have an interest in having a source of readily available water as well.²³ Nothing seems to have come out of this offer, and so a year later they decided on another way to provide an emergency supply. This time, Lambeth's directors asked several fire insurance companies whether they would be interested in making a contribution to keeping the company's steam engine ready to run at all times, which meant that there could always be an immediate supply of water in case of fire. This could be done for around £150 to £200 per year, but this was still too large an investment for Lambeth Waterworks to make on its own.²⁴ However, the Phoenix Fire Office declined, and none of the other insurance companies that were approached replied.

Despite this lack of cooperation, Lambeth Waterworks intended to do whatever was in their power to provide water in case of fire, as the directors perceived it as their "duty to make such provision for the safety of the Public as the Nature of their undertaking would admit but that the Circumstances of the Company would not permit".²⁵ It was mentioned at the same time that the company had already lent its assistance in helping to extinguish a fire near Blackfriars Bridge, and all its employees were ordered to procure water as soon as

²² LMA/ACC/2558/LA/1/1 Lambeth Waterworks, minutes, 25 April 1785.

²³ Ibid., 16 Aug. 1785.

²⁴ Ibid., 25 July 1786.

²⁵ Ibid., 15 Aug. 1786.

possible in case of fire.²⁶ It is clear, therefore, that the directors of at least this company saw providing water for free in case of fire as a public service that was part and parcel of being a water company.

Another occasion, albeit less frequent, in which the companies provided a free supply of water was during periods of acute shortages, such as severe frost. On several occasions over the eighteenth century cold spells resulted in the freezing over of available sources of water, and in certain years even the Thames froze over. For example, in January 1776, a particularly cold winter, it was reported that water had never been scarcer and that in many places there were difficulties securing a supply.²⁷ This scarcity of water was reflected in its price: during a cold spell in January 1789, people at Windsor and Camberwell complained that water had become so limited that they had to pay increased prices to waterbearers.²⁸ Several newspapers reminded the public to be vigilant with fire, as there was no access to water to deal with a conflagration.²⁹ In fact, at a fire in 1795 there was no water available as all the pipes were frozen, and the water had to be carried from half a mile away via carts.³⁰

With this acute scarcity of water the companies tried their best to keep supplying water, first and foremost to their own customers but also to the general public, even though they also encountered their own difficulties. Frost affected the supply network in various ways: water in the pipes would freeze, and the turncocks could not be opened, and so the companies could not keep their supply the usual way. Generally, they established standpipes in the streets, and in these cases it was emphasised that this was not just a substitute for the water supply to their own customers, but also for all other people who

²⁶ LMA/ACC/2558/LA/1/1 Lambeth Waterworks, minutes, 25 July and 15 Aug. 1786.

²⁷ *Morning Post and Daily Advertiser*, 30 Jan. 1776.

²⁸ *World*, 13 Jan. 1789; *Public Advertiser*, 15 Jan. 1789.

²⁹ See e.g. *London Chronicle*, 13 Jan. 1776; or *Star*, 22 Jan. 1795.

³⁰ *Lloyd's Evening Post*, 26 Jan. 1795.

were without access to water. For example, in 1763 York Buildings Waterworks announced in the *Public Advertiser* that it had “ordered a great Number of Stand Pipes to be placed in the Streets for the Convenience of their Tenants; and after they are served, they have also ordered, that all other Persons, whether belonging to the New River Water Works or others, be also served.”³¹ The same sentiment was shown by the New River Company later in the century, when during a frost in February 1784 the directors expressed their willingness to accommodate not only their own tenants but also the general public in times of frost.³² The company also set up standpipes to provide for the public during a severe frost in January 1795.³³ Similarly, the managers of London Bridge Waterworks gave “express orders (...) to permit every person to take water from our standpipes without the least discrimination whether they are a tenant to [the New River Company] or ours”, because of the “present scarcity and distress for water” during a cold spell in late 1788, when even the Thames was frozen over.³⁴

In order to maintain this supply, the companies had to keep their engines running, which again carried an extra cost they could not hope to retrieve.³⁵ As in their provision against fire, the companies bore this expense and kept on supplying the public, including those who were not their paying customers. So what were the motivations of the directors for doing this? The following sections examine, firstly, whether they were compelled by law to do so, and then explores other reasons.

³¹ York Buildings Waterworks, letter in *Public Advertiser*, 21 Jan. 1763.

³² LMA/ACC/2558/NR/1/2 New River Company, minutes, 5 Feb. 1784.

³³ LMA/ACC/2558/NR/1/4 New River Company, minutes, 26 Jan. 1795.

³⁴ LMA/ACC/2558/MW/C/15/291 Richard Till, letter to the New River Company, 1788.

³⁵ *Gazetteer and London Daily Advertiser*, 21 Jan. 1763. Also see LMA/ACC/2558/LB/2/45, London Bridge Waterworks, frost expenses, 1820.

7.2. Laws and leases.

The aftermath of the Great Fire had, in addition to stimulating the introduction of a new system of fire insurance, also provided the impetus for new laws that addressed the fire hazards inherent in early modern cities. These laws focused on the urban built environment, fire-fighting equipment, and finally, by the early eighteenth century, the supply of water. The 1667 Rebuilding Act regulated the material with which new houses could be built, as well as determining the width of the streets.³⁶ New houses were to be made of brick or stone instead of timber, with strict regulations of height, number of storeys, and party walls. In addition, houses were no longer allowed to project out over the street to ensure an adequate fire gap.³⁷

In the same year, the Corporation of London passed an act “for Preventing and Suppressing of Fires”, which addressed the lack of fire-fighting materials.³⁸ This act ordered that the City be divided in four quarters, each with their own supply of buckets, ladders, fire-hooks, and squirts. The City’s twelve main livery companies were required to provide an engine each, in addition to keeping their own supply of buckets and ladders.³⁹ The act also made provisions for domestic houses, and each householder was required to prepare a secure place in their property to place hot ashes.⁴⁰ While the 1667 act only referred to the administrative City of London and not the whole metropolis, a later act of 1708 “for better preventing mischiefs that may happen by fire” (the Parish Pump Act) made similar

³⁶ 19 Car II c. 3, *Act for rebuilding the City of London*, 1667.

³⁷ Reddaway, *Rebuilding*, pp. 80-1.

³⁸ Corporation of London, *An Act (of 1667) for preventing and suppressing fires within the City of London and liberties thereof* (London, Clark, 1676). Hereafter, Fire Prevention Act.

³⁹ They had been required to keep some equipment since the 1640s. Porter, *Great Fire*, pp. 16-7.

⁴⁰ Blackstone, *Fire service*, p. 47.

legislation for the whole of London.⁴¹ Under these new regulations every parish, both inside as well as outside the City, was required to provide fire-fighting equipment, including an engine, the cost of which would be borne by taxes.⁴²

The 1708 Parish Pump Act also addressed the supply of water in case of fire, and implicitly made this a responsibility of the water supply companies, by legislating that water could be taken from the pipes in the streets. The act's focus was on quick access to water: it made parish officers responsible for providing fireplugs in the supply pipes and placing notices on the houses in front of which these plugs were located, so water could be accessed quickly.⁴³ It also encouraged company employees to act swiftly: the first turncock on the scene was to be paid ten shillings for opening the plugs in the streets that were connected to the fire engine.⁴⁴ At this time, the annual salary of the turncocks was £20, and so the extra ten shillings would have been a sizable incentive to work quickly and try to claim the prize.⁴⁵ The companies themselves, however, were not mentioned in the act, even though it effectively meant that their water was being taken, and there is no evidence to suggest that they opposed the measures. The free use of their water therefore seems to have been accepted by the time this act was passed.

In fact, the water companies had been supplying water at fires from the very beginning of a commercial water supply. Peter Morris, the founder of London Bridge Waterworks, had needed to obtain a lease from the City Corporation in order to be allowed to construct

⁴¹ 7 An c. 17, *Act for better preventing mischiefs that may happen by fire*, 1708. Also known, and hereafter referred to, as the Parish Pump Act. This act succeeded a 1707 act of the same name, but included some clarification on boundaries that were not clear in the original act. There were no other significant changes.

⁴² It also acknowledged the public usefulness of the fire insurance crews by granting the watermen that were employed by the fire insurance companies immunity from being impressed into the navy or army, as it was recognised that they had more skill and were more helpful at a fire than others. Parish Pump Act.

⁴³ Parish Pump Act.

⁴⁴ Holloway, *Courage high*, p. 23.

⁴⁵ Ward, R., *London's New River* (London, Historical Publications, 2003), p. 83.

waterwheels under London Bridge and sell water. As part of this lease, there was a clause that stipulated the provision of free water in case of fire. This clause was initially very minimal: London Bridge Waterworks, “for the service of the City”, had to provide water to a few central locations where it could then be used freely to fight fires. In the event that people used this water when there was no fire, the company had the right to quit this part of the agreement all together and remove these pipes.⁴⁶ However, over time, the arrangements for providing an emergency supply became more extensive. In 1604, as Broken Wharf Waterworks requested an additional lease from the City, the clause with regards to providing free water had expanded to allowing the City the right to break open its pipes whenever there was a fire and obtain water straight from there.⁴⁷

As new companies required access to public space in order to set up and lay out their infrastructure, the legislative powers, whether belonging to the City Corporation or Parliament, could negotiate something in return. A requirement to provide part of their supply to the public in case of emergencies could therefore be used to ensure that companies’ use of public space was more than just a necessary commercial transaction. Indeed, much of the rhetoric surrounding the start-up of new companies focused on the public good that they could do, notably fire prevention. For instance, the original Chelsea Waterworks proposal stated that in the company’s reservoirs there would always be water “not only to supply the ordinary Occasions of the Inhabitants, but will also answer all other Calls in Case of Fire, the Pestilence, or any Exigency whatsoever.”⁴⁸ In addition, the company was allowed to construct their higher reservoirs in the royal parks because these would,

⁴⁶ LMA/ACC/2558/MW/C/15/222/2 London Bridge Waterworks, lease for first arch of London Bridge, 1581.

⁴⁷ Ward, *New River*, p. 18.

⁴⁸ LMA/ACC/2558/CH/1/47/1 Chelsea Waterworks, proposal, c. 1720.

apart from serving an ornamental function, be useful in case of fire.⁴⁹ Moreover, William Capell, the Earl of Essex, allowed the company to make improvements to the basins because the company's "Works which are of Publick Benefit".⁵⁰

Similarly, in their attempts to obtain permission from Parliament, the Colne instigators emphasised the company's usefulness in case of fire, and Lambeth Waterworks' founders, in order to obtain the Act of Parliament necessary for their establishment, organised a petition for local residents to sign, asking for Lambeth to be supplied "with water for domestic uses and in cases of fire".⁵¹ While not required by law, the willingness and intention to provide an emergency supply was aimed at gaining permission to set up as a company. While this arrangement to sweeten the deal for the public helps explain why they provided water in case of fire, it does not account for their efforts in times of frost, as this was never mentioned in the leases, and neither does it fully explain the efforts that the companies, as evidenced by Lambeth Waterworks' example, were willing to go to. There were therefore other considerations at play.

7.3. Publicity.

While the water companies were not paid for providing an emergency supply, they did get something in return: their activities helped to generate positive publicity. The efforts of quickly managing to supply water at a fire were frequently praised in the public press. Chelsea Waterworks, for example, was commended in a report in the *London Evening Post*

⁴⁹ LMA/ACC/2558/CH/1/1 Chelsea Waterworks, minutes, Aug. 1725.

⁵⁰ LMA/ACC/2558/CH/1/3 Chelsea Waterworks, minutes, 17 April 1729.

⁵¹ LMA/ACC/2558/LA/1/1 Lambeth Waterworks, minutes, 30 April 1785

as its turncocks had acted swiftly in supplying water to a fire in the cotton library in Westminster in 1731.⁵² Similarly, York Buildings was praised for its help at a January 1767 fire on the Strand, and the New River Company for its assistance at a 1799 fire in Islington.⁵³ Occasions when companies went above and beyond their general call of duty were especially subject to public praise. When in April 1765 a fire broke out near Bancroft's Almshouses, it was discovered that the parish officers had neglected their duty to provide fireplugs in the main that ran through the street, and the fire had threatened to burn down the whole row. The foreman of West Ham Waterworks "generously ran, with his Gang of Labouring-men to their Assistance, where they (...) with their Axes cut open the Main, by which means there was immediately Water enough".⁵⁴

While it is difficult to ascertain exactly how these messages were generated — there were no professional journalists, and it could be that the directors submitted the praise for their companies themselves — it is clear that publicity surrounding an emergency supply was important to the companies. When in the late 1740s there had been suggestions that London Bridge Waterworks had not acted swiftly enough to supply water to fight a fire in the City, the company's secretary responded by writing an open letter "to acquaint the Publick, that nothing was wanting on their Parts".⁵⁵ The letter emphasised the extent to which the company had gone to ensure a sufficient supply: all other mains had been shut for the duration, and three mains that ran close to the fire had all been opened via fireplugs as well as by cutting them open, and so "the Supply (...) must have been far more than

⁵² *London Evening Post*, 9 Nov. 1731.

⁵³ *London Evening Post*, 24 Jan. 1767; *New Lloyd's Evening Post*, 2 Jan. 1799.

⁵⁴ *Public Advertiser*, 20 April 1765.

⁵⁵ Secretary to London Bridge Waterworks, letter in *General Advertiser*, 30 March 1748.

sufficient for the Service required”.⁵⁶ The secretary then took the opportunity to advertise the power of the company by adding: “for it is very well known, that no Mains belonging to any Works in London, of equal Diameters, can vent so great a Quantity of Water as those as these Works”.⁵⁷

Another occasion in which the secretary of a water company felt compelled to ensure that the publicity surrounding emergency supply was correct occurred in 1759 in east London. West Ham Waterworks had been commended in the press for its efforts in providing water to extinguish a fire in Ratcliff that had destroyed several houses. It was mentioned in the *Gazetteer* that most of Queen Street would have been destroyed if it were not for the West Ham company, which provided the only water available and that supplied the engines all night and most of the next day.⁵⁸ On reading this, the clerk of Shadwell Waterworks issued a letter to *Lloyd’s Evening Post*, which had also carried the notice, to “acquaint the Public” that there was never a fire in Queen Street. In fact, the fire had been in Narrow Street, Ratcliff, where it was “immediately and effectively supply’d by the Waterworks in Shadwell”.⁵⁹

Both these incidents involving the erroneous reports of water supplied for fire fighting show how important the publicity generated was to the companies. In the case of London Bridge Waterworks, there had been insinuations that the company had been unable to supply water at the fire, an implication that the company wanted to dispel. The inability to provide water at a fire would suggest that the company was not fully up to the task of supplying water. It was an opportunity to demonstrate in public their capacity to produce

⁵⁶ The secretary begged those who were deprived of their usual water service to excuse the company “upon this melancholly Occasion” until the pipes could be repaired. *General Advertiser*, 30 March 1748.

⁵⁷ *General Advertiser*, 30 March 1748.

⁵⁸ *Gazetteer and London Daily Advertiser*, 4 Jan. 1759.

⁵⁹ Clerk to Shadwell Waterworks, letter in *Lloyd’s Evening Post*, 6 Jan. 1759.

water, and the ensuing publicity provided a free advertisement for the company that could potentially attract new customers.

Another result of the publicity was that it showed that the company in question could help protect houses from fire if there was a service pipe in the street. It was thus a beneficial thing to have in that respect, apart from the question of whether a household wanted a supply laid in their houses. Protection against fire was a selling point: as West Ham Waterworks was starting up, its directors had placed an advertisement in the *Public Advertiser* aimed at the inhabitants of the area where they had laid their mains, to inform them that “they have made Provision to supply them with a sufficient Quantity of Water to answer all Purposes for Family Use, and to assist them gratis, in the Times of any future Calamity, that may happen by Fire.”⁶⁰ While there is no evidence of customers’ motivation to choose a company based on fire protection, the fact that the public altercation between West Ham and Shadwell Waterworks took place at a time of rivalry between these companies is an indication that their role in fire protection might have played a part in the competition for a share of the east London water market.

As in the case of supply at fires, publicity was also generated by the companies’ efforts to supply during severe frost. When newspaper reports in January 1763 suggested that the waterwheels under London Bridge were entirely stopped by the frost and water in general was very scarce, the *Gazetteer* announced that most of the water still supplied in the city came from the New River Company, as all other waterworks were frozen.⁶¹ The newspaper praised the directors of this company as they had “particularly exerted themselves in

⁶⁰ West Ham Waterworks, advertisement in *Public Advertiser*, 28 Nov. 1767.

⁶¹ *London Chronicle*, 1 Jan. 1763; *Gazetteer and London Daily Advertiser*, 18 Jan. 1763.

furnishing several parts with water, by setting up wooden cocks".⁶² A few days later, the proprietors of York Buildings Waterworks published an advertisement in the *Public Advertiser* to rectify this. They thought it was "incumbent on them to advertise the Public, that their Works are not, nor can be stopp'd, whilst any Water runs in the Thames, as they work by Fire Engines".⁶³ The same day, London Bridge Waterworks was praised in the *Gazetteer* as they had gone to a very great expense of keeping their steam engine running day and night to take over the task of the waterwheels.⁶⁴ Again, it was important for the companies that the public knew they still supplied, and that they went to great efforts to do so even under adverse circumstances.

The publicity also provided an opportunity for the companies to advertise themselves as superior to their rivals, which is what the invocation of technological prowess, as shown especially by the York Buildings Waterworks, seems to imply. While York Buildings and London Bridge Waterworks did not compete on price with the New River Company, showing themselves as superior in the provision of water during an acute shortage had the potential to attract customers, and provides a reason why it was so important to manage their public image carefully.

However, other evidence suggests that it was not considered good behaviour to attract new customers based on disaster situations such as frost. As in the situation described in chapter six, when one company burned down or was incapacitated by any other reason, it was considered unseemly to profit from such misfortune. In December 1788, during a severe frost, both the New River Company as well as London Bridge Waterworks had set up

⁶² *Gazetteer and London Daily Advertiser*, 18 Jan. 1763.

⁶³ York Buildings Waterworks, letter in *Public Advertiser*, 21 Jan. 1763. A 'fire engine' is a steam engine in this context.

⁶⁴ *Gazetteer and London Daily Advertiser*, 21 Jan. 1763.

standpipes to supply the City. When several London Bridge tenants had gone to a New River standpipe to fetch water they had been told that they would only be supplied if they became New River tenants after the frost broke. On finding out about this, the secretary to London Bridge Waterworks, Richard Till, wrote a letter to the New River Company's directors to accuse them of profiteering from the public's distress at this time. Till thought that this was "illiberal behaviour" and emphasised that London Bridge Waterworks would "pursue the same liberal plan of accommodating the public at large without the smallest idea of interest".⁶⁵ While providing a supply in emergencies can be seen as a way of self-interest for the companies, as it had the potential to attract new customers, the wording of Richard Till's letter suggests that, at least for London Bridge Waterworks, other considerations played a role as well. The term 'liberal', at this time, before it gained its economic and political connotations, mainly meant 'generous' and 'magnanimous', as well as carrying the suggestion of the characteristics of a worthy or noble person.⁶⁶ Both these meanings are significant for the examination of the directors' decisions to supply water for free. It places the practice of providing an emergency supply in the context of eighteenth-century philanthropy, and touches on both its charitable aspects, as well as the civic aspect of being involved in institutional charity — a reminder that even in a commercial market economy, moral considerations had a part to play in understanding economic relations.

⁶⁵ LMA/ACC/2558/MW/C/15/291, Richard Till, letter to New River Company, Dec. 1788.

⁶⁶ From the Latin *liberalis*, generous. Oxford English Dictionary.

7.4. Philanthropy, projecting, and a *zeitgeist* of improvement.

Philanthropy in the eighteenth century was a multi-faceted activity. On one side, it fitted in a longer tradition of giving. Charity played a central role in religious life, and was considered to be a necessary activity of all good Christians.⁶⁷ In this light, the water companies supplied free water in emergencies because it was the good and moral thing to do, satisfying the directors' religious and ethical obligations to the greater good, as well as providing a sense of self-satisfaction. But benevolence was not just voluntary; early modern morality made it an almost mandatory activity — a form of *noblesse oblige*.⁶⁸ As the wealthy were provided with power, prosperity, and leisure time by the possession of their estates, they were expected to use these assets towards the promotion of the public good in return.⁶⁹ Charity, therefore, was as much a result of social obligation as of a benevolent spirit.

But charity and philanthropy were also social practices, and reflected on those who took part in it. This needs to be understood in the context of views about 'projecting' and the eighteenth-century business world more generally. Late seventeenth and eighteenth-century entrepreneurs often combined ideals of improvement with financial schemes.⁷⁰ The word 'projects', as these came to be called, had many meanings, but they always had a mixture of improvement, public benefit, and money-making about them.⁷¹ They included social welfare schemes, land improvements such as drainage, reclamation, and irrigation,

⁶⁷ Andrew, D.T., *Philanthropy and police, London charity in the eighteenth century* (Princeton, Princeton University Press, 1989), pp. 13, 15.

⁶⁸ *Ibid.*, p. 14.

⁶⁹ Pocock, J.G.A., *Virtue, commerce, and history: essays on political thought and history, chiefly in the eighteenth century* (Cambridge, Cambridge University Press, 1985), p. 103.

⁷⁰ Yamamoto, K., 'Piety, profit and public service', p. 810.

⁷¹ Thomas, J.H., 'Thomas Neale, a seventeenth-century projector' (PhD thesis, Southampton University, 1979), p. xviii.

and involved investments in pumping technology and mine draining.⁷² Commercial waterworks fit into this definition as well: there was the public benefit of neighbourhoods being supplied with water, but, as the previous chapter has shown, there was an opportunity to make money as well.

While enthusiasm for projects seem to have spanned the long eighteenth century, they carried negative connotations as well, as a result of their association with unscrupulous schemes for making money. Often, people were accused of pretending to promote the public good for their own self-enrichment. Daniel Defoe, writing in the 1690s, noted that there had been attempts at the transformation of the meaning of the word: he saw projectors as a positive force who found new ideas to address the difficulties of the time.⁷³ Over the course of the eighteenth century, from Bernard Mandeville's *Fable of the Bees* (1714) to Adam Smith's *The Wealth of Nations* (1776), the notion that profiting was always opposed to the public good was challenged.⁷⁴

As seen in the previous chapter, there were certainly some who questioned the morality of making profits from the provision of water, and there was a concern that the companies would be seen in a negative light. For instance, such sentiment was expressed in a letter in *Lloyd's Evening Post* by 'B.Y.Z.' on W. Efford's Colne proposals.⁷⁵ He wrote: "upon the whole, this bears the face of a private job (...) calculated to serve private purposes, notwithstanding the good of the Publick is pretended."⁷⁶ Similarly, during the 1821 Select Committee hearings of the investigation into London's water supply, James Weale of the Anti-Water

⁷² Thomas, 'Neale', pp. xv-xvi.

⁷³ Novak, M.E., 'Introduction', in M.E. Novak, ed., *The age of projects* (Toronto, University of Toronto Press, 2008), pp. 3-26, pp. 3, 6.

⁷⁴ See Slack, P., *Reformation to improvement, public welfare in early modern England* (Oxford, Clarendon Press, 1999), p. 120.

⁷⁵ B.Y.Z., letter in *Lloyd's Evening Post*, 5 Dec. 1764.

⁷⁶ Ibid.

Monopoly Association, accused the owners of the West Middlesex Company of being “a set of city speculators” who were involved in the companies “without any permanent regard to the public benefit, but merely to promote (...) speculation in the shares of the companies”.⁷⁷ Weale claimed that the new companies had only been established for their directors to enrich themselves. He believed that, if west London’s water supply had really been as bad as to warrant additional companies, some local wealthy inhabitants would have been the investors, as had been the case in other situations where improvements were needed: for the construction of docks and canals, it had been those who were most inconvenienced who had made the first move to invest.⁷⁸

These accusations were strongly denied by the company, whose spokesperson asserted that its shareholders “were men of fortune, living in the district, and builders and people of that description, and not city speculators, for there are only thirteen that live in the city.”⁷⁹ More supporting evidence put forward against the notion was that between 1810 and 1820 many of the shareholders who had sold had done so at a loss, and not made any profit.⁸⁰ However, an earlier incident from 1808, when two directors had sold shares at a 50 per cent premium in order to enrich themselves, was carefully kept silent at the Select Committee hearings.⁸¹ The other directors, who had not wanted their shares sold at the open market to avoid a bubble-effect, had made them repay the profits they had made to the company and

⁷⁷ Graham-Leigh, J., *London's water wars: the competition for London's water supply in the nineteenth century* (London, Francis Boutle, 2000), p. 92.

⁷⁸ *Minutes of evidence taken before the select committee on the supply of water to the metropolis*, PP 1821 (706), p. 91. Also, Weale thought it was suspicious that the instigators of this company had previously been involved with Manchester Waterworks.

⁷⁹ *Select committee*, PP 1821 (706), p. 168. This did not have to mean anything: many of those trading in the City would have owned a dwelling house in the fashionable West End.

⁸⁰ *Ibid.*, p. 175.

⁸¹ Graham-Leigh, *London's water wars*, pp. 87-8.

they had to resign from their positions.⁸² Obviously, there had been speculators involved with the new waterworks, but the companies were keen to rid themselves of these associations.

The water companies clearly wanted to project an image of public service, and disassociate themselves from connotations of speculation and self-enrichment. A way to do this was to act, as the London Bridge Waterworks secretary put it, as 'liberal men'. In the late seventeenth and eighteenth century, businesses and careers were built on credit and trust, and the ability to utilise this stood or fell with the individual's, or the company's, reputation. Entrepreneurs therefore needed to guard and actively manage their image as trustworthy and reliable individuals, and did this by sending out signals that they belonged to a class of respectable and dependable citizens.⁸³ Such signals to show that one was a reliable and trustworthy gentleman included having a house at a good address, such as the West End or even a country estate, manners in dress, language, and etiquette. Dedicating part of one's money and time to the public good formed part of this as well.⁸⁴

For those who had made their fortune through trade or financial speculation, spending part of their time and money on ventures that benefitted the public could assuage the negative cultural notions of 'immorality' that were attached to wealth acquired this way.⁸⁵ This led to a myriad of clubs, associations, and societies that were dedicated to the improvement of science, knowledge, or the support of the needy, but which also functioned as a way for gentleman-entrepreneurs to meet, form networks, and establish their

⁸² Graham-Leigh, *London's water wars*, pp. 86-8.

⁸³ Mokyr, J., *The enlightened economy, an economic history of Britain, 1700-1850* (London, Yale University Press, 2009), p. 370.

⁸⁴ Pocock, *Virtue*, p. 103; Mokyr, *Enlightened economy*, p. 370.

⁸⁵ See e.g. merchants that made their fortune in the West India trade, Hancock, D., *Citizens of the World, London merchants and the integration of the British Atlantic community, 1735-1785* (Cambridge, Cambridge University Press, 1995). For the morality of earned money, see Defoe, quoted in Yamamoto, 'Piety, profit and public service', p. 810.

reputation.⁸⁶ Over the course of the eighteenth century, philanthropy increasingly gained practical values as well.⁸⁷ Benevolent charity was coupled with utilitarianism in order to find solutions for pressing problems, and answer the manpower needs of the state to address these.⁸⁸ Especially in London, this kind of practical philanthropy was evident in the establishment of institutional charities that had specific aims, most notably the several hospitals catering for the poor, abandoned, or sick.⁸⁹

Charitable societies and voluntary organisations, whether resulting from social obligation or as a vehicle to establish social capital, in addition to projects, played an important role in the production of public goods through collective action, for which elsewhere in Europe the state or the church had a large role to play. The building of roads, bridges, lighthouses, and canals was largely financed by private subscription, as were social amenities such as hospitals, schools, and orphanages. While in some cases there was hope of making a profit, and in the case of improving local trade and employment there was certainly a level of self-interest involved, often the investors were also motivated by the desire to improve society.⁹⁰

⁸⁶ Mokyr, *Enlightened economy*, p. 375; See e.g. Clark, P., *British clubs and societies, 1580-1800* (Oxford, Clarendon Press, 2000).

⁸⁷ Andrew, *Philanthropy*, p. 20.

⁸⁸ White, J., *London in the eighteenth century: a great and monstrous thing* (London, the Bodley Head, 2012), p. 469.

⁸⁹ Clark, *Clubs*, pp. 82, 95; White, *London*, pp. 469, 479.

⁹⁰ Mokyr, *Enlightened economy*, p. 381.

7.5. The men behind the companies.⁹¹

While motives are always difficult to ascribe, an evaluation of the background of the companies' directors can provide some indications whether cultural values as described above played a role in their decision to provide water for free. What was the social class of those at the helm of the water companies? How had they gained their wealth? Where did they live? Would they want to improve their reputations? The following section aims to find an answer to the motivation of the directors by considering the background of those who made the important decisions for the water companies. Who they were, and what their station was in life, provides an indication of whether they would be motivated by reputation, or if they would have had other incentives for the free provision of an emergency supply.

For this analysis, the names of all those who attended board meetings over the course of one year per decade have been taken down.⁹² Data was available for Chelsea Waterworks (from their start-up in 1720s through to 1800), the New River Company (1769-1800), London Bridge Waterworks (1776-1800), and Lambeth Waterworks (from their start-up in

⁹¹ They were all men. In 1789 the widow of a Lambeth Waterworks shareholder, Mrs Young, complained that the company had not alerted her to its meetings, which, as she held the vote attached to the share now, she had wished to attend. It was resolved that she was to be notified of the meetings, but "it be recommended to Mrs Young not to attend the Meeting of the Proprietors on Account of the Impropriety of a woman sitting at a Public Board". LMA/ACC/2558/LA/1/1 Lambeth Waterworks, minutes, 4 Aug. 1789.

⁹² The companies were governed in slightly different ways. The New River Company and West Ham Waterworks — and Lambeth, at least during the years of analysis — were basically run as partnerships: they had relatively few shareholders, of which a fixed number was allowed to attend meetings (29, the number of the original Adventurer's shares, in the case of the New River Company). The New River Company chose a governor, deputy governor, and treasurer from this number, while the Lambeth company's directors took turns to be the chair. Chelsea Waterworks and London Bridge Waterworks, on the other hand, had a large number of shareholders and annual elections were held to choose those who would be in charge of the company for the next year. London Bridge Waterworks elected nine managers (and a treasurer), none of which was officially in charge. Chelsea Waterworks elected directors, whose number varied over the years, as well as a governor and deputy governor (in 1750 the company did not have a deputy governor). Rudden, B., *The New River: a legal history* (Oxford, Clarendon Press, 1985), p. 3; LMA/ACC/2558/LA/1/1 Lambeth Waterworks, minutes.

the 1780s to 1800).⁹³ For the companies that started up during the eighteenth century, the first group of directors has been included in the analysis as well. Complete lists of directors for each company, including their active years, occupation, and address, are included in the appendix.

The companies all displayed a great continuity of directors over the century, with many of them staying on over two, or even three, decades. For instance, Peter Holford was the New River Company's governor for the entire period under study, with several other Holford family members in regular attendance over the decades. Richard Clark was a manager of London Bridge Waterworks in 1780, 1790, and 1800, and Peter Calmel a director of Chelsea Waterworks between 1760 and 1790, during which time he was chosen to serve as the company's governor. In the case of the companies that had elected managers, this indicates that the shareholders were overall happy with their company's management. It also suggests that the directors themselves saw their role in the company as a job that required constant attention, and were involved with the direction their company was taking.

It is difficult to categorise social status in a meaningful way, as the line between old and new money became increasingly blurred over the course of the eighteenth century, and for many of the directors there was not enough data available to securely assign them to a social strata. Nevertheless, based on the information that could be gathered about them, it is possible to draw out some similarities as well as differences between the directors of the companies. The New River Company was dominated by 'new moneyed men'. Of the 50 directors that attended meetings over the years examined, 26 have been identified with some certainty. Many of these were new money: people or families who had made their

⁹³ LMA/ACC/2558/CH/1/1 to 16; LMA/ACC/2558/NR/1/1 to 5; LMA/ACC/2558/LB/1/1 to 5; LMA/ACC/2558/LA/1/1 and 2.

wealth as merchants, bankers, and through investments in the East India and South Sea companies. George Colebrooke, for example, deputy governor in 1770, was a banker and speculator in various companies, including the East India Company, of which he was governor.⁹⁴ He had inherited his share from his father James Colebrooke, a prosperous London mercer and banker, who had bought shares in 1732.⁹⁵ Other examples include Aime Garnault, who was the son of a Huguenot merchant, Isaac Walker, a linen merchant, and John Darker, a hop merchant.⁹⁶

Since by the start of the eighteenth century a New River Company share provided a decent income (see figure 6.10), those who had inherited shares were often able to live off their wealth.⁹⁷ Members of the Holford family, for example, had initially been barristers and lower gentry with some landed estates, but by the early nineteenth century George Peter Holford was able to renovate and rebuilt the Weston Bird estate as a result of the family's combined New River Company and South Sea Company wealth.⁹⁸ The Berners, who provided two deputy governors as well as a treasurer during the period studied, were from a merchant family. In the mid-seventeenth century a Berners had invested in four New River shares, which proved to be lucrative. Over time the family intermarried into other merchant

⁹⁴ Bowen, H.V., 'Colebrooke, Sir George, second baronet (1729–1809)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn. Jan. 2008): [<http://www.oxforddnb.com/view/article/37301>, accessed 8 July 2012].

⁹⁵ Galili, R., *Arnos Grove and the Walker Family* (London, Southgate District Civic Trust, 2008), p. 19; Rudden, *New River*, p. 64.

⁹⁶ Galili, *Walker family*; Fisher, D.R., 'Loveden, Edward Loveden (?1751-1822), of Buscot Park, Berks.', in *The history of Parliament: the House of Commons 1790-1820* (Woodbridge, Boydell and Brewer, 1986), online edn.: [<http://www.historyofparliamentonline.org/volume/1790-1820/member/loveden-edward-loveden-1751-1822>, accessed 9 July 2012].

⁹⁷ The New River Company had some shareholders who had inherited their shares for several generations. While the London Bridge Waterworks was older, its original owners, the Morris family, had sold the company in 1703 and new shares had been issued (see chapter 3). Its late-eighteenth-century shareholders therefore could not have been in possession of their shares for longer than a century.

⁹⁸ Spencer, H., 'Holford, George Peter (1767-1839), of 15 Bolton Street, Mdx. and Weston Birt, Glos.', in D.R. Fisher, ed., *The history of Parliament: the House of Commons 1820-1832* (Cambridge, Cambridge University Press, 2009), online edn.: [<http://www.historyofparliamentonline.org/volume/1820-1832/member/holford-george-1767-1839>, accessed 9 July 2012].

wealth: Henry Berners' mother, for example, was the daughter of Robert Raworth, a prominent East India merchant who was also a director of the Bank of England.⁹⁹ Their wealth earned in trade enabled them to move to Woolverstone Hall in Suffolk. Similarly, Isaac Walker had bought Arnos Grove on a fortune made through his trade.¹⁰⁰ While not solely the result of investment in New River shares, these landed estates were bought largely on City wealth.

Although a few New River Company directors held knighthoods or baronetcies, these were rarely an indication of old money: the Hulse baronetcy was only in the family for its second generation, and earned on merit — their father had been a physician to King George I and II.¹⁰¹ George Colebrooke became a baronet, but only because his older brother James died without issue.¹⁰² Noel Edwards had married into a title: the baronetcy had been created for his father in law, who gained it through his work in the Navy.¹⁰³ While these were titled people, the titles were newly created, and often earned by merit or service rather than inherited through generations.

London Bridge Waterworks was similar to the New River Company in the sense that its managers came from a similar background. They included several merchants and bankers, although these seem to have been less wealthy than the New River shareholders: there is no evidence that they owned country estates. While some of this company's managers

⁹⁹ Wynne, S., 'Berners, William (1679-1712), of Moore Place, Much Hadham, Herts.', in D. Hayton, E. Cruickshanks, and S. Handley, eds., *The history of Parliament: the House of Commons 1690-1715* (Woodbridge, Boydell and Brewer, 2002), online edn.: [<http://www.historyofparliamentonline.org/volume/1690-1715/member/berniers-william-1679-1712>, accessed 8 July 2012].

¹⁰⁰ Galili, *Walker family*.

¹⁰¹ Mosley, C., ed., *Burke's Peerage, Baronetage & Knightage, 107th edition, volume 2* (Wilmington, Delaware, Burke's Peerage Ltd, 2003), p. 1996.

¹⁰² Bowen, 'Colebrooke'.

¹⁰³ Thorne, R.G., 'Edwards (afterwards Noel), Gerard Noel (1759-1838), of Exton Park, Rutland' in R. Thorne, ed., *The history of Parliament: the House of Commons 1790-1820* (Woodbridge, Boydell and Brewer, 1986), online edn.: [[http://www.historyofparliamentonline.org/volume/1790-1820/member/edwards-\(afterwards-noel\)-gerard-noel-1759-1838](http://www.historyofparliamentonline.org/volume/1790-1820/member/edwards-(afterwards-noel)-gerard-noel-1759-1838), accessed 9 July 2012].

could be considered old money, these showed a history of not being adverse to involvement in the financial world: James Winter Lake, while from an old landowning family, had a grandfather who had been the governor of the Africa Company, and was involved in the Hudson Bay Company himself. Other managers included Peter Cazalet, who was also a director of the Bank of England, as well as two aldermen. One of them, Richard Clark, noted earlier, became Lord Mayor of London.¹⁰⁴

Both these companies had been in continuous existence for almost two centuries before the directors identified above became involved, but for two other companies data are available about those that were involved during their start-up year: Chelsea Waterworks and Lambeth Waterworks. The latter company's directors had a similar profile as London Bridge Waterworks, although there were also some significant differences. Of the 14 people involved in the company's start-up in 1785, four were merchants. More specifically, three of them were coal merchants. As Lambeth Waterworks ran a steam engine from the very start, these people had an obvious link with the practical side of running the company, as well as an additional interest in its success. Other directors included a smith, an ironfounder, a pipeborer, an engineer, and a bricklayer; all professions which were directly related to practical tasks in the construction of the company's infrastructure. Indeed, the directors actively worked for the company: Thomas Simpson, their engineer, was said to have been responsible for the set-up of the engine, but also of its maintenance, attending to it on average twice a week.¹⁰⁵ While each of these directors must have been rich enough to invest in the £100 shares (most of them held more than one share), they were essentially

¹⁰⁴ Mercer, M.J., 'Clark, Richard (1739–1831)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn. May 2006): [<http://www.oxforddnb.com/view/article/5470>, accessed 8 July 2012].

¹⁰⁵ LMA/ACC/2558/LA/1/2 Lambeth Waterworks, minutes, 17 Oct. 1797. Simpson was engineer to Chelsea Waterworks as well.

people who had a trade, and although some were merchants, they traded in goods that had an active link with the work the company undertook.

Chelsea Waterworks had a director of similar social status in its early years: John Rowley, who had made the waterwheels for the company.¹⁰⁶ However, most of the people involved in this company showed a quite different profile from the previously mentioned companies. The Chelsea Waterworks' directors were from diverse backgrounds: they were a mix of West End landowners, military and naval officers, public office holders, and some clergymen, with only a few merchants and bankers. Of the 23 directors that managed the company in its start-up years (mid to late 1720s), at least nine had had a career in the army or navy, and people from these professions remained active in the company over the course of the century.¹⁰⁷

These were careers in which one could show loyal service to the Crown.¹⁰⁸ Eighteenth-century army commissions were purchased, and allowed wealthy, non-landed individuals access to the aristocracy: by assuring the Crown of a trustworthy performance one could gain cultural acceptance and respectability, and even, if one excelled in battle, obtain a title.¹⁰⁹ Military commissions were untainted by the negative connotations of 'new money', although they held the opportunity to make prize-money, and offered the possibility of power and glory. Offices in the King's household, or careers in the clergy, provided similar

¹⁰⁶ Intriguingly, this company also had two physicians as early directors. There is no evidence whether they had an interest in a better water supply because of their profession or were involved for other reasons.

¹⁰⁷ A possibility is that the shares were acquired and passed on through networks. This was likely to have occurred through existing connections, such as family connections – shares were often given to daughters or as part of marriage contracts – or professional connections. Other army officers could have found out about the company through their colleagues. See also the Eckersall family, members of which sat on the company's board throughout the century, and the reverends Cutts Barton and Charles Barton, who kept both their Chelsea shares and their job in the family.

¹⁰⁸ Allen, D.W., *The institutional revolution, measurement and the economic emergence of the modern world* (Chicago and London, University of Chicago Press, 2012), p. 54.

¹⁰⁹ *Ibid.*, pp. 147, 154.

opportunities to forge a respected career and establish social capital.¹¹⁰ In addition, two peers were involved in this company's start-up, Viscount Molesworth and Lord Grosvenor, but both only inherited their titles after the period that they were active in the company; they had been younger sons, who came into their titles after an older brother's demise.¹¹¹ Later directors included the occasional landowner, and some bankers, with more people having other trade connections. However, the military and public office presence remained strong throughout the century.

Many of those involved in the companies also engaged in charitable work: Richard Clark, manager of London Bridge Waterworks, was also a treasurer of the Brideswell Royal Hospital, and several of the New River directors were described as philanthropists.¹¹² Chelsea Waterworks' directors were evidently involved in charities as well: when the Westminster Infirmary for the Poor, Sick, and Lane asked for a reduction on their water-rent the company refused to allow this as they needed to cover their expenses, but the directors were keen to point out that many of them were already involved with the hospital and contributed in other ways.¹¹³ Similarly, in 1798 the company was publicly listed as contributing £500 for the defence of the country.¹¹⁴ This linked their company with charity, and with patriotic endeavour, both of which reflected well on their reputation.

However, the directors' philanthropy did not have to be motivated solely by their public image: the case of Isaac Walker, a New River Company director, hints at religious reasons. Walker, a Quaker who made his wealth as a linen merchant, was known as a philanthropist

¹¹⁰ Allen, *Institutional revolution*, pp. 14-5, 54.

¹¹¹ Chichester, H.M., 'Molesworth, Richard, third Viscount Molesworth (1680–1758)', in J. Spain, ed., *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn. Oct. 2007): [<http://www.oxforddnb.com/view/article/18900>, accessed 23 June 2009].

In addition, one of the colonels later became the Earl of Westmoreland.

¹¹² See Galili, *Walker family*; and Spencer, 'Holford'.

¹¹³ LMA/ACC/2558/CH/1/3 Chelsea Waterworks, minutes, 4 Dec. 1729.

¹¹⁴ *True Briton*, 15 Nov. 1798.

and it was mentioned in his obituary (probably written by his son John, also a director) that he retired early from his drapery business and spent the rest of his life in “well-directed benevolence”.¹¹⁵ He had also been on record in connection with another charitable scheme during the severe winter of 1767: during this winter, as food was scarce, Walker and fellow Quakers Samuel Hoare and David and John Barclay, had bought food wholesale and sold it cheaply to the poor.¹¹⁶ While this took place before he became involved with the New River Company, it shows a similar concern as did the emergency supply of water during scarcity in cold winters.

However, another factor in the background of all directors is also evident: many of them were local to the area that their company supplied. Of the 23 London Bridge Waterworks managers, at least eleven had an address where they could (and probably would) have had access to their company’s water. In addition, the aldermen and mayor on the board would have had a political and local interest in the protection of the City of London. Similarly, of 72 Chelsea directors over the course of the century, all but eight could be traced to a location. Of the 66 addresses available, at least 42 were located in the area supplied by the Chelsea Waterworks, as depicted in figure 7.2.¹¹⁷ For the Lambeth directors only a smaller sample is available, but even here, out of 18 men, six lived in or near Lambeth. Finally, local links for the New River Company directors were less evident: only few addresses have been found and many of these were country estates. This is likely a result of the social status of these directors: at a certain level of wealth the possession of a country estate was expected. It is

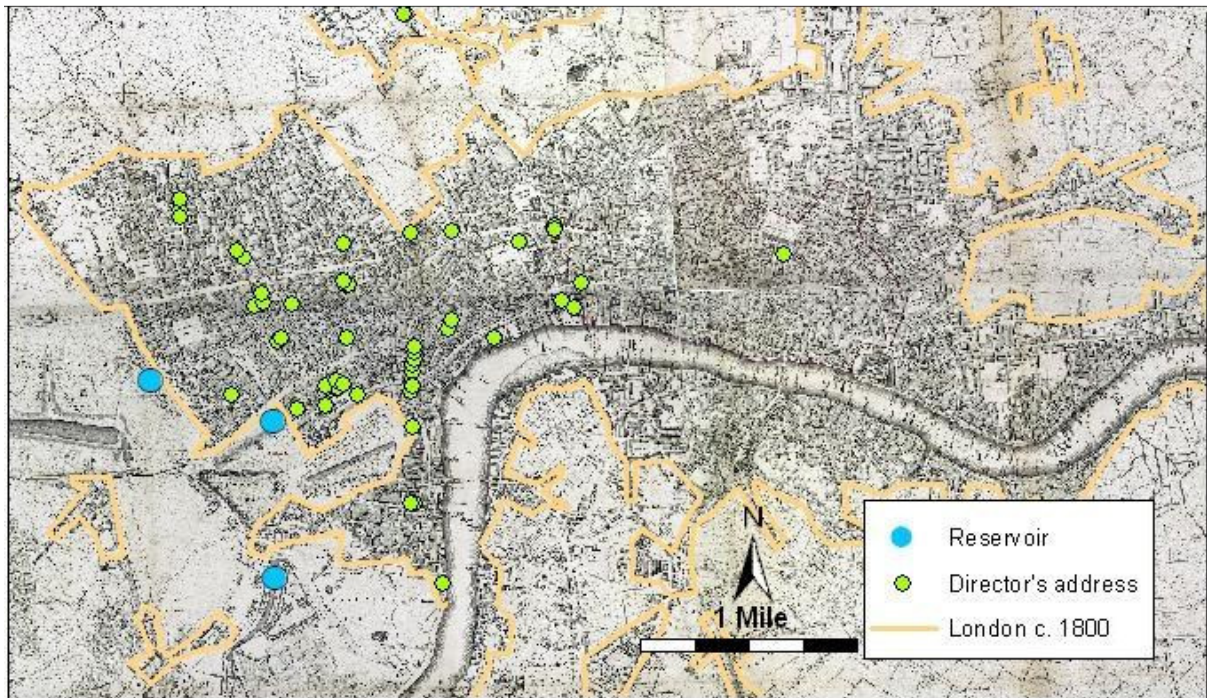
¹¹⁵ Galili, *Walker family*, p. 66.

¹¹⁶ *Ibid.*, p. 44.

¹¹⁷ Others listed addressed in the City of London – which could have been a business address, meaning that they might have had a house elsewhere, or landed estates, which, as many of these were addresses taken at the time of death, was the main address named in their will, and not the place where they had lived for much of their active business lives.

however very likely that they would have inhabited houses in London as well, not least because of the frequency of the directors' meetings — which generally took place once every two weeks.

Figure 7. 2. Known locations of Chelsea Waterworks' directors, 1725-1800.



Source: Chelsea Waterworks' register of wills, 1731-1765, LMA/ACC/2558/CH/1/626A, and 1763-1871, LMA/ACC/2558/CH/1/626B. Base-map is Stockdale.

While the local link might seem obvious, as all directors had to attend meetings in London, it also gave the directors a level of self-interest in their company's works, both in terms of water supply but also as a protection against fire for their own area. There is evidence that the local interest played a role in directors' decision regarding company policy. When Richard Lyttleton was the Chelsea Waterworks' governor, the company often held its meetings at his house on Cavendish Square. During one meeting in 1760 the directors decided that as there were new houses being constructed in the vicinity of the

square, it would be good for the company to lay pipes there, as well as improve the water supply to the neighbourhood, even though they had not received applications yet.¹¹⁸ Local knowledge therefore played a role in the decision making process. In the same vein, the local interest would have welcomed the addition of a better emergency water supply in the directors' own streets.

Clearly, James Weale's claim that the waterworks' directors had been speculators and not those inconvenienced by an inferior water supply was wrong. While some might have been involved for financial advantage, the fact that many also benefitted themselves from their company's actions points to a level of self-interest and neighbourhood improvement. In fact, on a list of people backing the 1767 Colne proposal, both Lord Grosvenor as well as Lord Portland were listed.¹¹⁹ As in the case of the Duke of Chandos, who had been instrumental in York Buildings' decision to expand towards his estate around Cavendish Square, involvement in a water company was both a business as well as a personal interest, as the supply of water and the better protection for fire improved their own property.

7.6. The free provision of water: motives.

Assigning motives is always difficult, and the reasons why the directors decided to supply for free were probably complex. Some of their actions were attributable to legal requirements: they were obliged to make their water available for everyone to take in case of fire. However, this does not explain the whole story. The companies cooperated beyond

¹¹⁸ LMA/ACC/2558/CH/1/12 Chelsea Waterworks, minutes, 22 Feb. 1760.

¹¹⁹ Thomas Grosvenor was in fact ordered to resign as a Chelsea Waterworks director because of his family's involvement. LMA/ACC/2558/CH/1/12 Chelsea Waterworks, minutes, 5 March 1767.

their legal requirements, destroying their pipes by axing them open, as the West Ham Waterworks foreman did, or considering building pipes and reservoirs specifically to aid fire fighting, as was the case with Lambeth Waterworks. In addition, the fact that they also supplied free water in another kind of emergency — frost — for which there was no legal requirement, points to the existence of other motives.

The rise of the press offered a platform for a growing public debate on the water market, as shown in chapter six. The positive publicity the companies' actions generated could sway this opinion towards a particular water company. Some directors were conscious of this fact, as evidenced by their actions, which could have provided an incentive to supply for free. There were several reasons why a positive public opinion was important. Firstly, the publicity was a free form of advertising: it showed the company could supply well and emphasised its technological prowess. In addition, it showed that having pipes in a street would be advantageous not only for a water supply but also to be protected against fire. Public helpfulness therefore had a marketing potential as a way of demonstrating one's superiority in times of emergency.

However, the publicity generated a range of additional advantages. Favourable comments on the water companies lent prestige to otherwise untoward ventures.¹²⁰ As the previous chapter has shown, critics accused the companies of making a profit on an essential good. As *Aquae Vindex* had accused the companies of 'locking the water away' from free access, giving it back to the public in times of need could be construed as

¹²⁰ Yamamoto, 'Piety, profit, and public service', p. 807.

deflecting this criticism. Partaking in philanthropy reflected well on a director's reputation as a good citizen, and by extension, on their business ventures.¹²¹

Finally, there was also an element of self interest: the technology and infrastructure of the companies were expensive, and fire was an ever-present and very real danger. It was in the companies' own interest to help ensure that their own buildings and the houses and properties of their customers did not burn down. While in theory the fire insurance companies' brigades could source water for their engines from all available supplies, in practice, as there was no adequate public emergency water supply and access to open water dwindled, they mainly depended on the various water companies, which had pipes in most of London's streets.

The water companies' directors therefore had a variety of reasons for providing this service. In particular, cultural notions of providing for the public good and Enlightenment ideals of improvement played a role, and as the waterworks were the only ones in the position to provide water in case of emergency, they took this role on for the public good. Providing water against fire became the charitable side of a profit making company, and those setting up new water companies in the eighteenth century emphasised both their potential for fire fighting as well as supplying the population with water. As profit-making companies, public service made their dividends appear more virtuous.

¹²¹ Lloyd, S., *Charity and poverty in England, c. 1680-1820* (Manchester, Manchester University Press, 2009), pp. 20, 31; Mokyr, *Enlightened economy*, p. 382.

Chapter 8. Conclusion.

This thesis has explored how London's expansion during the eighteenth century affected drainage of its surface area and the supply of water to its inhabitants and industries. It has shown how access to open water diminished, both as a result of the spread of the built-up area and as an outcome of expanded drainage networks that channelled water underground. This separation between the city's population and open water was bridged by water companies and sewer commissions. These institutions grew progressively more important during the eighteenth century as their infrastructural systems increasingly became the vessels through which access to water was mediated. The study of the expansion of these large and technological advanced networks of drainage and supply, and of their growing influence in the distribution and management of water, has provided a unique lens through which to view the organisational changes, economic transformations, technological innovations, as well as conflicts and discussions about access and control that took place in eighteenth-century London.

London's growth during the eighteenth century posed challenges both for drainage and water supply. The water companies as well as the sewer commissions sought to extend their networks in parallel with urban growth and this involved creating an extended network of pipes and sewers that covered a larger area often at higher elevation and which served an ever increasing number of customers. The institutions' ability to deal with this expansion depended on several factors, and how the networks were built and managed reflected a complex set of relationships, in which environmental and social changes often co-determined each other. The creation of the physical systems that increasingly determined

access to water revolved around socio-economic changes, technological knowledge and innovation, ideological views regarding the market, and power relations. In particular, the ability to extend both water and sewerage networks rested on identifying not just what was of benefit to the private consumer but also how a public good, such as drainage or water with which to fight fires, could be provided to the general population.

The construction and growth of large infrastructure systems is underpinned by technological ability, institutional structures, legislative powers, and economic conditions.¹ Technological knowledge helps to explain the kinds of networks that were created, although this differed for supply as opposed to drainage. For drainage networks, technological ability formed no barrier to their expansion or functioning: the sewer system relied mainly on gravity and no major innovations occurred during the century that would have increased the efficiency of the system. For supply, on the other hand, the quality and expansion of service was heavily dependent on the availability of machinery to raise water to higher elevations. The main challenge for most of the companies that supplied eighteenth-century London was to raise their water high enough to be distributed through the entire network, often across considerable distance from the source, both in terms of length as well as elevation. The amount of water a company was able to raise was often the factor that limited its expansion, and for this reason, the companies invested heavily in the technology necessary to extend their networks across larger areas and at higher elevations.

London's geography played a crucial role in the technological choices open to the companies. The location of their intakes determined the choice between constructing a water-tower or a reservoir, as well as whether a waterwheel was a feasible option. Another

¹ Hughes, T.P., *Networks of power: electrification in western society, 1880-1930* (Baltimore, Johns Hopkins University Press, 1993), pp. 2, 462.

important factor was the spatial pattern of a company's customers, which determined the extent to which water had to be raised. Technological choices were also a reflection of knowledge about innovations in complementary fields: the early adopters of steam engines were all aware of its potential uses through their other ventures, mainly in mining. A company's geography, its particular needs, and the success of its technological forays played out in the way water supply networks developed and the different degrees of success achieved by each company. The New River Company, for example, was able to become the largest and most powerful water supplier partly because it had no need to experiment with expensive new technologies, and was able to adopt steam power only when it had become more efficient. Other companies, such as York Buildings Waterworks, which relied from an early stage on new steam technology to provide an adequate supply to its customers, were less fortunate and grew more slowly, if at all.

Physical factors also influenced the institutional structure of London's water system. Water follows gravity which means that households cannot be excluded from drainage in the same way that they can be from the supply of water. The result of this was that drainage remained in the hands of public authorities, whereas water supply, which was often conducted against gravitational forces and could as such easily exclude houses, offered possibilities for private business. Getting rid of excess water was therefore always seen as a public good whereas the provision of water was increasingly viewed as a private act of consumption. The institutional arrangements that managed water in eighteenth-century London were therefore very different.

The institutions' legislative frameworks had a decisive impact on the shape taken by the water systems. Parliamentary consent was required for new companies seeking to establish

a foothold in the capital. Some potential companies — most notably those related to the various attempts to use the river Colne — failed at this stage, but once promoters had gained permission to start operations, their main constraints were financial and technological. The commissioners of sewers, on the other hand, faced a larger challenge, especially regarding expansion of the network. Because Tudor statutes prevented them from constructing new sewers, they depended on private builders and developers to extend the drainage system to new neighbourhoods. The commissioners, however, retained the power to manage and tax these private sewers, as well as the ability to set certain regulations regarding size and building material. In addition, the sewer commissions could force people within their jurisdiction to contribute, and through public/private collaboration new houses were connected to the network as the city expanded.

While physical factors and technological capacity influenced the way that water supply networks were constructed, broader political and economic processes that prioritised market relations allowed companies to be established as the main means of supply. Constructing the infrastructure to supply water to private houses required a huge financial outlay, much more so than a network that supplied only a few public pumps. Economic as well as institutional changes that accompanied the Financial Revolution of the eighteenth century made possible the financing of the water companies, both in relation to the availability of much larger flows of money, as well as changes in the legal framework relating to private property, which facilitated a greater security in long-term financial investments. Moneyed individuals were able to set up and invest in water companies because they had reason to believe they could expect a return for their money in the long term. In addition, Enlightenment concepts of improvement and progress provided the opportunity to present

water companies as socially acceptable investment projects: improvement of the city through means of a better water supply as well as protection for fire was emphasised as much as the personal benefit a shareholder might gain from investing.

However, they still had to make their investments in infrastructure worthwhile. As a result of this, the expansion of the supply network was heavily influenced by London's social geography. As calculations by the managers of the waterworks show, expansion into an area was dependent on the proportion of households likely to take up a supply. Deciding factors to the expansion of the supply network were wealth, and distance from the source of supply, since this dictated the cost. Affluent households were more willing to pay for a private supply and, as chapters five and six have shown, the richer West End attracted several companies that sought to extend their reach into this area.

But this was not the whole story: as the high percentages of houses supplied with water in some neighbourhoods show, it was not only the wealthy who laid on a supply. A decisive factor as to whether or not people took up a commercial water supply was their distance from other sources, which would have necessitated a household having to allocate more resources to fetching a water supply rather than to buy it. The fact that distance to alternative sources was one of the factors taken into account by both the directors of the Lambeth as well as of the Chelsea Waterworks as they deliberated on whether to extend to certain neighbourhoods points out the importance of distance to water in shaping the growth of the water network.

Technological knowledge, topography, legislation, as well as economic factors therefore had a profound impact on the structure and functioning of eighteenth-century London's water system. As such it can be seen as a socio-physical network, which both transformed

London's physical waterscape as well as the social relations inscribed therein.² Access to water became increasingly controlled by the institutions in charge of these networks, and both the companies as well as the commissioners managed this through physical as well as through behavioural means. Some of the physical measures were inherent in the infrastructure, such as the commissions' solution of constructing grates over the sewers to filter out solids, while on the supply side it was actively managed through the switching on and off of services.

The behavioural methods the institutions employed were mostly financial. The sewer commissions regulated misuse of their networks by issuing fines for illegal practices, and also ensured even contributions from all those who benefitted from repairs. The water companies essentially kept their water 'locked up' in the pipes, and consumers had to pay to get access. The price that was charged determined both who was able to access the water, as well as how heavily this impacted on a household's resources. While access to water was not a problem as long as there were alternative ways of supply, the gradual disappearance of these different sources meant that the companies' networks increasingly became the main ways by which water circulated. As a result, their power over access became a pertinent topic of debate.

Market relations became the primary means by which access to water was obtained, and in the late eighteenth and early nineteenth centuries it was the specific arrangements of this market that were questioned. Largely because of the expense of constructing the network of pipes, pumps, and reservoirs, and the need to ensure adequate returns on their outlay, the companies sought to protect their investments and avoided potentially ruinous

² Swyngedouw, E., *Social power and the urbanization of water* (Oxford, Oxford University Press, 2004), pp. 9-10, 23.

competition on the open market. As a result they colluded in non-competitive arrangements or even created spatial monopolies, both of which forced consumers to pay a higher price than would have been the case if there had been true competition. This situation was a cause for serious concern, especially in relation to the poor and working-class population. The water companies had expanded their market penetration over the course of the eighteenth century, and in some places by the end of the century over 80 per cent of houses were connected to the commercial network. Many of these houses were relatively cheap, often occupied by artisans and the middling groups who, while not at the bottom of society, were equally not particularly wealthy. For these individuals, payment for water, which previously had been available from public pumps and streams, as well as the Thames, was a significant strain on income and much of the concern about pricing policy revolved around the ability of these groups, and the poor, to gain access to water.

The morality of the market was the subject of public debate that revolved around the effects of monopolistic practices on the price, and therefore people's ability to purchase water. In common with debates about the way that the commercial grain market operated, and the concerns this generated in relation to the ability of the poor to purchase wheat, the key question in relation to water was the extent of regulation the market required in order to maintain access to what was, after all, a necessity of life. Many of the commentators championed a free market with multiple companies active within one area and advocated letting the free market take care of the price mechanism. While free-market price dynamics happened locally at certain periods of competition during the eighteenth century, and at an especially large scale during the early decades of the nineteenth century, it disadvantaged

the companies to such a degree that they eventually resorted to new agreements, reflecting the natural monopolistic characteristics of a piped water supply.

Other commentators thought that the antidote to high prices was to improve the public supply. In particular, *Aquae Vindex*, writing in the 1770s, called on the city to improve its free supply for the use of the poor, meaning that the companies should function solely as a luxury service for those able and willing to pay for water. In essence, his solution aimed to reduce the distance between households and water again, so the effort required in fetching it would consume fewer household resources than paying for a commercial supply. This would, effectively, have reduced the reliance of the poor on the water companies, and therefore on the institutions that mediated distance between the provision and consumption of water.

This thesis has argued that in addition to integrating social, economic, and political processes with environmental history, geography needs to be incorporated into the analysis of the institutions that emerged to drain London and provide its inhabitants with water.³ In particular, the thesis has examined how water management was linked to, and influenced by, geology and topography, as well as the economic factors, societal values, legal frameworks and institutional changes that occurred during the eighteenth century. This complex situation did not arise entirely afresh: several of the water companies and the commissioners of sewers were inherited from the sixteenth and seventeenth centuries — and some of the processes that gained momentum during the eighteenth century continued into the nineteenth. While changes in the eighteenth century were part of a continuing story, in some regards they also reflected a break with the past. The introduction of new

³ Massard-Guilbaud, G. and Mosley, S., 'Breaking down borders: integrating the social and environmental in history', in G. Massard-Guilbaud and S. Mosley, eds., *Common ground: integrating the social and environmental in history* (Newcastle upon Tyne, Cambridge Scholars Publishing, 2011), pp. 1-15, p. 4.

technologies, organisational structures, and economic transformations that were particular to that period, coupled with urban growth, provided qualitatively new conditions that influenced the structure and functioning of the water market.

The thesis has used the way water was managed, both in relation to supply and drainage, as a lens through which to study changes in institutional arrangements. As such it has examined the growing role played by private institutions in an expanding city where, in relation to the provision of water, mediating the distance between supply and demand became the central problem. In doing so it has highlighted the process by which a public good became a private commodity. It has also explored the ideological underpinnings of the market provision of water and the institutional arrangements that distinguished private supply from a public system of drainage. The two were related: the disappearance of surface water was of material importance in explaining how access became increasingly difficult for a growing number of people. The city's changing waterscape, therefore, needs to be studied as a whole if we are to fully understand how water became a commodity in eighteenth-century London.

Appendix A. Directors of Chelsea Waterworks, 1720s-1800.

Name	Function	Start-up (1724-28)	1730	1740	1750	1760	1770	1780	1790	1800	Occupation	Address	Other information
Col. Francis Negus	Gov. (1720s, 1730)										Army, courtier, and MP	Covent Garden	
Col. Robert Gardner	Dep. Gov. (1720s)										Army	St Margaret Westminster	
Maj. Henry Foubert											Army, academy and riding school	King Street, St James Westminster	
John Eckersall												St James Westminster	
Alex. Stevenson												St James Westminster	
John Rowley											Engineer and instrument maker	Business address in Fleet Street	
Capt. Ant. LaMeloniere											Navy		
James Scanlan												St George Hanover Square	
Col. John Fane											Army, MP, became Earl of Westmoreland	Listed at Horse Grenadier Guards	
Sir John Colbatch											Physician	St Martin-in-the-Fields	
Capt. Thomas King											Navy	Combermere, Chester	His wife was Dame Philadelphia Cotton, widow to a landed fortune.
Daniel Ivie												Chelsea	Robert Ivie had shares in Millbank Waterworks and possibly became director as part of the take-over of this company
Maj. Jos. Watts											Army	St James Westminster	
Col./Lord Molesworth											Army, MP, became Viscount Molesworth	Kensington	
Maj. Andrew Doyle											Army	St Martin-in-the-Fields	He mentioned John Eckersall in his will
John Huggins												St Martin's Lane	
Gov. Phillipps													
Charles Whithers												Clifford Street, St James Westminster	
Sir John Shadwell											MD/Physician	Windmill Street, St James Westminster	

Name	Function	Start-up (1724-28)	1730	1740	1750	1760	1770	1780	1790	1800	Occupation	Address	Other information
Charles Staples											Possibly army. His will mentioned a half-pay pension from Ireland.	Craven Street, Strand; used to live in St Ann Westminster	In his will he lamented that half of what had been settled on his beloved wife Theadosia Staples in their marriage contract was lost by being subscribed into South Sea stock, and that other considerable sums had been lost by being invested in Chelsea Waterworks
Henry Joynes											Architect and builder	Kensington Palace	Friend of James Eckersall
John Ewer											Goldsmith	St Martin-in-the-Fields	
Sir Robert Grosvenor, Bart.											Landowner	Inner Temple; Mill Bank, Westminster	
Sir Thomas Frederick	Dep. Gov. (1730)											St Ann Westminster	
James Eckersall											Clerk to Queen Anne's kitchen	St James Westminster	Owned Drayton House, lands in Lancashire, stocks and shares in Bank of England, South Sea, Royal Africa Company
Francis Whitworth				?								Clifford Street, Burlington Gardens	
Col. Richard Peirson (later Maj. Gen.)											Army, banking	Marylebone	Had an interest in Scottish banking company
Thomas Scawen											MP	Carshalton, Surrey	From landed family with significant commercial interests. Father and uncle contributed to Bank of England and East India Company, his mother was a merchant's daughter.
Christopher Tilson	Gov. (1740)											St Margaret Westminster	
Col. John Cope											Army		
John LaRoche	Dep. Gov. (1740), Gov (1750)											Pall Mall, King Street	
Col. John Jeffereys											Army	Pall Mall, Mount Street	Left his shares to Richard Lyddleton
Benjamin Periam												Islington	
Thomas Ripley											Architect and investor	Middle Scotland Yard; St Martin-in-the-Fields	
Thomas Bowen												Middle Temple; Somerset House, Strand	

Name	Function	Start-up (1724-28)	1730	1740	1750	1760	1770	1780	1790	1800	Occupation	Address	Other information
John Tilson													Nephew of Christopher Tilson
Sir Charles Whitworth	Dep. Gov. (1760), Gov. (1770)			?							MP	St James Westminster; Leybourne, Kent	Inherited family estates. Son of Francis Whitworth?
Edward Ravenell												Chandois Street, Covent Garden; Greek Street, St Ann Westminster	
Andrew Drummond											Goldsmith/banker	Charing Cross	Younger brother of a Viscount
John Drummond											Banker	Charing Cross	Son of Andrew Drummond
John Ludbey												St James Westminster	Owned several houses near Piccadilly and Swallow street
John Thornhagh											Nottinghamshire landowner	Shireoaks, Nottinghamshire	
Sir Richard Lyttelton, Knt of Bath	Gov. (1760)										Gov. of Minorca and MP	Cavendish Square, Marylebone	Was the executor of John Jeffereys; younger son of Baron Lyttleton
Peter Calmel	Gov. (1780)											Thatched House Court, St James Westminster; later of Park Place, St James	
The Rev. Dr. Cutts Barton											Rector, later Dean	St Andrews Holborn; later Bristol	
Solomon Durell											Riding school	King Street, Golden Square, St James Westminster	Nephew of Henry Foubert
Edmund Bramston													
Col. Michael Delabene											Army	Park Place, St James Westminster	
John Alexander Stainsby	Dep. Gov. (1770)										Barrister	Southampton Street, Bloomsbury	
Sir James LaRoche, Bart.	Gov. (1790)										MP	From Bodmin	
Richard Crop												Westoe, Cambridge; Lincoln's Inn Fields; St George Hanover Square	West India merchant connections: his sister Susanna Crop of Fenchurch Street was married into the Long family. Samuel Long, Beestin Long, and Charles Long were his nephews.

Name	Function	Start-up (1724-28)	1730	1740	1750	1760	1770	1780	1790	1800	Occupation	Address	Other information
Thomas Bishop	Dep. Gov. (1780, 1790)											Newport Street; Hayes	
George Eckersall												Lincoln's Inn Fields	Son of James Eckersall
Henry Dagge												Great Russell Street	
George Schutz												Marylebone	
Wither Bramston												Hall Place, Southampton	Of Oakley Hall and neighbour of Jane Austen
Richard Bowen												Throgmorton Street	Son of Thomas Bowen
Maj. William Gascoigne											Army	Charlotte Street; Rathbone Place	
George Lane Blount											Public Office	St John's College, Cambridge	
James Mathias											Merchant	City of London	
William Gascoigne jr.											Navy (?)	Admiralty	
												Cavendish Street, Marylebone; Sloane Street, Knightsbridge; Great Missenden; Weddington Hall, Warwick	Mentioned in business connections and legacies of Peter Calmel.
William Crawford	Gov. (1800)												
Bryan Broughton											Clerk in Foreign Office, from merchant's family		
Charles Boynton Wood	Dep. Gov. (1800)											St Pancras	
James Hyde													
John Eckersall												Mickleham, Surrey	Cousin of James Eckersall
Col. Wilford (later Maj. Gen.)											Army		
John Manship												Queen Square, St George the Martyr	Son of cloth merchant, director of East India Company
Rev. Owen Perrott Edwards											Clerk and rector of St Bart Smithsfield		
Thomas Barton Bowen												Middle Temple; Marylebone	
Rev. Charles Barton											Clerk, Rector	St Andrews Holborn	
Charles Rivington Broughton											Secretary of State's office, Lawyer		

Sources: most of the data in this table has been taken from LMA/ACC/2558/CH/1/626A Chelsea Waterworks, register of wills, 1731-1765;

LMA/ACC/2558/CH/1/626B Chelsea Waterworks, register of wills, 1763-1871; LMA/ACC/2558/CH/1/586 Chelsea Waterworks, share

transfers; LMA/ACC/2558/CH/1/587 Chelsea Waterworks, share transfers. Additional information has been gathered from a) probate records: will of Charles Staples, TNA/PROB/11/788/399; Will of James Eckersall, TNA/PROB/11/801/339; Will of Richard Peirson, TNA/PROB/11/1076/102; b) Oxford Dictionary of National Biography: Seccombe, T., 'Negus, Francis (*bap.* 1670, *d.* 1732)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, 2004): [<http://www.oxforddnb.com/view/article/19856>, accessed 23 June 2009]; Chichester, H.M., 'Molesworth, Richard, third Viscount Molesworth (1680–1758)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn. Oct. 2007): [<http://www.oxforddnb.com/view/article/18900>, accessed 23 June 2009]; Appleby, J.H., 'Rowley, John (c.1668–1728)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn, Jan 2008 [<http://www.oxforddnb.com/view/article/37919>, accessed 5 July 2012]; Cook, H.J., 'Colbatch, Sir John (*bap.* 1666?, *d.* 1729)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn., Jan 2008): [<http://www.oxforddnb.com/view/article/5833>, accessed 23 June 2009]; Spain, J., 'Fane, John, seventh earl of Westmorland (*bap.* 1686, *d.* 1762)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn., May 2009): [<http://www.oxforddnb.com/view/article/9134>, accessed 5 July 2012]; c) Survey of London: Sheppard, F.H.W., 'Kingly and Carnaby Street Area', in F.H.W. Sheppard, ed., *Survey of London: volumes 31 and 32: St James Westminster, Part 2* (London, Institute of Historical Research, 1963), pp. 176-195, online edn.: [<http://www.british-history.ac.uk/report.aspx?compid=41470>, accessed 29 August 2012].

Appendix B. Directors of the New River Company, 1770-1800.

Some of the directors have been grouped in networks to draw out their connections.

Name	Function	1770	1780	1790	1800	Occupation	Address	Other information
Peter Holford	Gov. (1770-1800)					Master in Chancery		His grandfather was a barrister, and acquired Weston Bird estate through marriage; P. Holford's father held a share in 1750
Robert Holford						Director of the South Sea Company, philanthropist		Son of P. Holford
George Peter Holford						MP	Bloomsbury; Weston Bird, Glos.	Son of P. Holford
Josiah Holford								Family of above (?)
Richard Holford								Family of above (?)
Sir George Colebrooke, Bart.	Dep. Gov. (1770)					Banker, MP	His bank had a City address	James Colebrooke (George's brother or father) held 2 shares in 1750; George was the younger son who inherited the baronetcy after his brother died
John Walker Heneage						MP, society man		Nephew of Colebrooke, possibly also related to the Walkers
Benjamin Keene						MP		Married Mary Ruck, whose ancestor James Ruck had been James Colebrooke's partner
Henry Berners	Treasurer (1770-1780)						Henrietta Street, Covent Garden	In 1750 William Berners (deceased) of Woolverstone Hall held 3 shares; these shares had been in the Berners family since the mid-seventeenth century
William Berners	Dep. Gov. (1780, 1800)						Woolverstone Hall, Suffolk	
Rev. Henry J Berners								
Charles Berners	Dep. Gov. (1790)							
Charles Berners jr.								
Richard Benyon							Bloomsbury Square	Married Hannah Hulse, daughter of Edward Hulse
Edward Hulse								Later became Bart. He and Richard were heirs to Edward Hulse, physician to the King
Richard Hulse	Treasurer (1790-1800)							

Name	Function	1770	1780	1790	1800	Occupation	Address	Other information
Aime Garnault						Son of merchant jeweller	Basinghall Street	His father was a Huguenot who fled from Paris
Samuel Garnault								Nephew of Aime Garnault
Thomas Ingram								Son in law of Aime Garnault
Cuthbert Fisher								Son in law of Aime Garnault
William Sitwell							Dyers Court, Aldermansbury	Also of Renishaw, Derby. Bequeathed several charitable gifts in his will
Mr. Phipps								Samuel Phipps of Lincolns Inn was the cousin of William Sitwell and mentioned in his will, as was Aime Garnault
Isaac Walker						Linen merchant	Cornhill; Arnos Grove	Quaker and philanthopist; Elizabeth Walker held a share in 1750, as well as Thomas Walker of Clifford Street
John Walker							Bedford Square; Arnos Grove	Isaac's son
John Darker						Hop merchant, MP		Son of a hop merchant in Clerkenwell; owned land in Northamptonshire and Leicestershire
Edward Loveden Loveden						MP, landowner	Buscot Park, Berks.	Buckinghamshire old gentry, he married several wealthy heiresses, one of which was the daughter of John Darker
Joseph Wilcocks							Hurley, Berks.	His father was Dean of Westminster
John Ashfordby							Cheshunt, Herts.	From old landowning family
Samuel Dixon								
Elias Brownsword								
William Southouse								
Rev. Mr. Tattersal								
William Harris								
Samuel Smith								Possibly held shares in trust for the Rucks
John Herbert								
Sir John Read, Bart								
Edward Lambert								
Nathaniel Dowding						Solicitor to the New River Company		
George Burley								
Sir Henry Gough Calthorpe, Bart						From merchant family		Henry Calthorpe of Soho Square had one share in 1750
John Lambert								
Thomas Watson								
Gerard Noel Edwards						Banker, MP		Noble family, but his father was illegitimate

Name	Function	1770	1780	1790	1800	Occupation	Address	Other information
John Payne								
Robert Smith								
Jacob Jeddere								
Henry Hoare								Likely to have been a member of the Hoare banker family
Robert Williams								
William Moffatt								
John Langston								

Sources: Information has been gathered from a) books: Rudden, B., *The New River: a legal history* (Oxford, Clarendon Press, 1985); Galili, R., *Arnos Grove and the Walker Family* (London, Southgate District Civic Trust, 2008); b) Oxford Dictionary of National Biography: Bowen, H.V., 'Colebrooke, Sir George, second baronet (1729–1809)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn., Jan 2008): [<http://www.oxforddnb.com/view/article/37301>, accessed 8 July 2012]; c) History of Parliament online: Fisher, D.R., 'Loveden, Edward Loveden (?1751-1822), of Buscot Park, Berks.', in *The History of Parliament: the House of Commons 1790-1820* (Woodbridge, Boydell and Brewer, 1986): [<http://www.historyofparliamentonline.org/volume/1790-1820/member/loveden-edward-loveden-1751-1822>, accessed 9 July 2012]; Thorne, R.G., 'Edwards (afterwards Noel), Gerard Noel (1759-1838), of Exton Park, Rutland' in R. Thorne, ed., *The History of Parliament: the House of Commons 1790-1820* (Woodbridge, Boydell and Brewer, 1986): [[http://www.historyofparliamentonline.org/volume/1790-1820/member/edwards-\(afterwards-noel\)-gerard-noel-1759-1838](http://www.historyofparliamentonline.org/volume/1790-1820/member/edwards-(afterwards-noel)-gerard-noel-1759-1838), accessed 9 July 2012]; Wynne, S., 'Berners, William (1679-1712), of Moore Place, Much Hadham, Herts.', in D. Hayton, E. Cruickshanks, and S. Handley, eds., *The History of Parliament: the House of Commons 1690-1715* (Woodbridge, Boydell and Brewer, 2002): [<http://www.historyofparliamentonline.org/volume/1690-1715/member/berniers-william-1679-1712>, accessed 8 July 2012]; Spencer, H., 'Holford, George Peter (1767-1839), of 15 Bolton Street, Mdx. and Weston Birt, Glos.', in D.R. Fisher, ed., *The History of Parliament: the House of Commons 1820-1832* (Cambridge, Cambridge University Press, 2009): [<http://www.historyofparliamentonline.org/volume/1820-1832/member/holford-george-1767-1839>, accessed 9 July 2012]; d) Probate records: Will of William Sitwell, TNA/PROB/11/1019/96.

Appendix C. Managers of London Bridge Waterworks, 1780-1800.

Name	Function	1780	1790	1800	Occupation	Address	Other information
Richard Clark	Manager				Lawyer, Alderman, Mayor	New Bridge Street	Was also treasurer of Royal Hospital of Brideswell; friend of Dr. Johnson; his wife was the daughter of John Pistor
Johnson Pistor	Manager				Woollen draper family	Bath, his sons lived in Walbrook	
Edward Ommanney	Manager				Had a Naval Agency	Bloomsbury Square	Owned lands in Lincoln
John Bradney	Manager				Possibly an apothecary	London Street, Fenchurch Street; Clapham, Surrey	
William Willis	Manager				Banker	Lombard Street	Reade, Willis, and Moorhouse has a partnership.
George Wyatt	Manager				Builder	Albion Place, Christchurch, Surrey	
Sir James Winter Lake, Bart.	Manager				Landowner		From an old landowners family; his grandfather was governor of the African Company
Bibeye Lake	Manager						Family of above
Samuel Evans	Manager					Shelley, Essex; Bowes, near Ongar	
Abraham Atkins	Manager					Clapham, Surrey	Edward Martin was his nephew
Edward Martin	Manager						Nephew of Abraham Atkins
Joseph Moorhouse	Manager				Banker	Lombard Street	Reade, Willis, and Moorhouse had a partnership.
John Tysoe Reade	Manager				Banker (?)		Reade, Willis, and Moorhouse had a partnership; since the others were bankers, Reade probably was too
Thomas Lesingham	Manager					Kensington	
Peter Cazalet	Manager				Merchant	Austin Friars	Also director of Bank of England
William Cazalet	Manager				Merchant	Austin Friars	Son of Peter Cazalet
William Field	Manager					Upper Thames Street; Canonbury, Islington	
Sir Claude Champion Crespigny, Bart.	Manager				Landowner	Camberwell, Surrey	From old Huguenot family
Edward Ellicott	Manager						
Thomas Perry	Manager					Berners Street, Oxford Street	
Charles Hamerton	Manager				Alderman	Whitefriars Dock	
Thomas Poynder	Manager					Bishopsgate Street	
James Wood	Treasurer					Lombard Street	

Source: most of the data in this table has been taken from: LMA/ACC/2558/LB/1/13 London Bridge Waterworks, stock ledger, 1802-1818;

LMA/ACC/2558/LB/1/16 London Bridge Waterworks, transfers of shares, 1708-1747; LMA/ACC/2558/LB/1/26 London Bridge Waterworks,

extracts from wills, 1782-1823. Additional information has been gathered from the Oxford Dictionary of National Biography: Mercer, M.J., 'Clark, Richard (1739–1831)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn. May 2006): [<http://www.oxforddnb.com/view/article/5470>, accessed 8 July 2012].

Appendix D. Directors of Lambeth Waterworks, 1785-1800.

Name	Function	Start-up (1785)	1790	1800	Occupation	Address
Benjamin Kennett sn.					Coal merchant	St Clement Danes
Benjamin Kennett jr.					Coal merchant	St Clement Danes
John Pinnick					Brassfounder	St George Bloomsbury
John Bligh	Treasurer and secretary				Coal merchant	St George Hanover Square
Francis Wall					Smith	St Saviour Southwark
James Lukin					Ironfounder	Christ Church, Surrey
Robert Young					Paviour	St Margaret Westminster
Thomas Simpson	Engineer				Engineer	Lived at Chelsea Waterworks
Edward Gwyn					Pipeborer and timber merchant	Belvidere Row, St Mary Lambeth
William Bonifant					Gentleman	St George Hanover Square
John Nichols					Bricklayer	St George Hanover Square
William Broadhurst						St George Hanover Square
William Leighton					Esquire	Charlton, Kent
George Pearson					Gentleman	Princes Street, St Mary Rotherhithe
John Thompson					Gentleman	St Mary Lambeth
Mr. Wood						
Robert Gatty					Attorney	Castle Court, London
George Leighton					Gentleman	Grove Lane, Camberwell
Mr. Eaton					Esquire	St George Hanover Square
Thomas Monday						

Source: most of the data in this table has been taken from: LMA/ACC/2558/LA/1/1650 Lambeth Waterworks, share transfers, 1786-1833; LMA/ACC/2558/LA/1/1768/1 Lambeth Waterworks, register of wills, 1794-1872.

Bibliography.

1. Primary sources.

1.1. London Metropolitan Archives.

Records of Chelsea Waterworks.

A. Directors of Chelsea Waterworks, minute books.

LMA/ACC/2558/CH/1/1, 1724-1726.

LMA/ACC/2558/CH/1/2, 1726-1728.

LMA/ACC/2558/CH/1/3, 1728-1730.

LMA/ACC/2558/CH/1/4, 1730-1731.

LMA/ACC/2558/CH/1/5, 1731-1733.

LMA/ACC/2558/CH/1/6, 1733-1735.

LMA/ACC/2558/CH/1/7, 1735-1736.

LMA/ACC/2558/CH/1/8, 1736-1739.

LMA/ACC/2558/CH/1/9, 1739-1743.

LMA/ACC/2558/CH/1/10, 1743-1748.

LMA/ACC/2558/CH/1/11, 1749-1759.

LMA/ACC/2558/CH/1/12, 1759-1772.

LMA/ACC/2558/CH/1/13, 1772-1781.

LMA/ACC/2558/CH/1/14, 1781-1790.

LMA/ACC/2558/CH/1/15, 1790-1797.

LMA/ACC/2448/CH/1/16, 1797-1803.

B. Chelsea Waterworks, other material.

LMA/ACC/2558/CH/1/47/1, Proposal, ca. 1720.

LMA/ACC/2558/CH/1/495, Subscribers to Chelsea Waterworks' shares, 1723-1728.

LMA/ACC/2558/CH/1/586, Share transfers, 1726-1737.

LMA/ACC/2558/CH/1/587, Share transfers, 1726-1764.

LMA/ACC/2558/CH/1/605, Dividend book, 1737-1760.

LMA/ACC/2558/CH/1/626A, Register of wills, 1731-1765.

LMA/ACC/2558/CH/1/626B, Register of wills, 1763-1871.

Records of Lambeth Waterworks.

A. Directors of Lambeth Waterworks, minute books.

LMA/ACC/2558/LA/1/1, 1785-1792.

LMA/ACC/2558/LA/1/2, 1792-1803.

B. Lambeth Waterworks, other material.

LMA/ACC/2558/LA/1/1650, Share transfers, 1786-1833.

LMA/ACC/2558/LA/1/1768/1, Register of wills, 1794-1872.

Records of London Bridge Waterworks.

A. Managers of London Bridge Waterworks, minute books.

LMA/ACC/2558/LB/1/1, 1776-1779.

LMA/ACC/2558/LB/1/2, 1779-1780.

LMA/ACC/2558/LB/1/3, 1780-1788.

LMA/ACC/2558/LB/1/4, 1788-1796.

LMA/ACC/2558/LB/1/5, 1796-1804.

B. London Bridge Waterworks, other material.

LMA/ACC/2558/LB/1/13, Stock ledger, 1802-1818.

LMA/ACC/2558/LB/1/16, Transfers of shares, 1708-1747.

LMA/ACC/2558/LB/1/20, Dividend book, 1786-1800.

LMA/ACC/2558/LB/1/26, Extracts from wills, 1782-1823.

LMA/ACC/2558/LB/2/45, London Bridge Waterworks, frost expenses, 1820.

LMA/ACC/2558/MW/C/15/12, List of proprietors, ca. 1700.

LMA/ACC/2558/MW/C/15/222/2, Lease for the first arch of London Bridge, 1581.

LMA/ACC/2558/MW/C/15/291, Agreement between London Bridge Waterworks and the New River Company, 1738.

Records of the New River Company.

A. Governors of the New River Company, minute books.

LMA/ACC/2558/NR/1/1, 1769-1778.

LMA/ACC/2558/NR/1/2, 1778-1786.

LMA/ACC/2558/NR/1/3, 1786-1792.

LMA/ACC/2558/NR/1/4, 1792-1798.

LMA/ACC/2558/NR/1/5, 1798-1804.

B. New River Company, other material.

LMA/ACC/2558/NR/9/29, Ledger, 1804.

LMA/ACC/2558/NR/12/1, Rent book, 1769.

LMA/ACC/2558/NR/13/1, Bundle of miscellaneous papers, c. 1600-1800.

LMA/ACC/2558/NR/13/188, Robert Mylne's commonplace book, c. 1766-1816.

LMA/ACC/2558/NR/13/207/3, Petition to be supplied with New River water, 1771.

Records of Shadwell Waterworks.

LMA/ACC/2558/MW/C/15/98, List of tenants of Shadwell Waterworks, c. 1720.

LMA/ACC/2558/EL/A/2/B28/1, Agreement between West Ham Waterworks and Shadwell Waterworks, 1785.

LMA/ACC/3077/12, Memorial to fire offices, 1794.

Records of City of London Commissioners of Sewers.

City of London Commissioners of Sewers, minute books.

LMA/CLA/6/AD/3/3, 1696-1705.

LMA/CLA/6/AD/3/6, 1719-1725.

LMA/CLA/6/AD/3/8, 1729-1732.

LMA/CLA/6/AD/3/9, 1732-1734.

LMA/CLA/6/AD/3/12, 1741-1743.

LMA/CLA/6/AD/3/16, 1751-1754.

LMA/CLA/6/AD/3/19, 1760-1763.

LMA/CLA/6/AD/4/9, 1772.

LMA/CLA/6/AD/4/29, 1792.

Records of Holborn and Finsbury Commissioners of Sewers.

Holborn and Finsbury Commissioners of Sewers, minute books.

LMA/HFCS/14, 1722-1730.

LMA/HFCS/16, 1730-1741.

LMA/HFCS/17, 1742-1763.

LMA/HFCS/18, 1763-1798.

Records of Surrey and Kent Commissioners of Sewers.

Surrey and Kent Commissioners of Sewers, minute books.

LMA/SKCS/42, 1699-1712.

LMA/SKCS/43, 1712-1728.

LMA/SKCS/44, 1728-1743.

LMA/SKCS/45, 1743-1755.

LMA/SKCS/46, 1755-1764.

LMA/SKCS/47, 1764-1774.

LMA/SKCS/55, 1776-1786.

LMA/SKCS/56, 1787-1799.

Records of Tower Hamlets Commissioners of Sewers.

Tower Hamlets Commissioners of Sewers, minute books.

LMA/THCS/11, 1729-1732.

LMA/THCS/13, 1740-1769.

LMA/THCS/15, 1760-1762.

Records of Westminster Commissioners of Sewers.

Westminster Commissioners of Sewers, minute books.

LMA/WCS/45, 1698-1703.

LMA/WCS/50, 1720-1724.

LMA/WCS/52, 1729-1734.

LMA/WCS/53, 1734-1745.

LMA/WCS/57, 1769-1775.

Westminster Commissioners of Sewers, index to the minute books.

LMA/WCS/87, 1659-1806.

Miscellaneous.

LMA/ACC/2558/EL/A/1/2, East London Waterworks, minutes of directors, 1807-1809.

LMA/ACC/2558/MW/C/15/99, List of tenants of Millbank Waterworks, 1715.

LMA/ACC/2558/MW/C/15/291, Richard Till, letter to the New River Company, 1788.

LMA/CLA/36/1/6 to 8, Thames Courts of Conservatory, minutes, 1714-1821.

LMA/COL/AC/9/1, City of London, "Cases relating to ye City of London", c. late 17th cent.-1755.

LMA/O/139/1, Survey of all the main, riders, and services on the land of Earl Northampton and adjacent, 1799.

LMA/SC/GL/NOB/C/46, Box with miscellaneous water related material, c. 1600-1950.

1.2. The National Archives.

TNA/T/1/248, Treasury Board papers, July-Dec. 1724.

TNA/T/1/252, Treasury Board papers, Jan.-May 1725.

TNA/PROB/11/788/399, Will of Charles Staples, 1751.

TNA/PROB/11/801/339, Will of James Eckersall, 1753.

TNA/PROB/11/1019/96, Will of William Sitwell, 1776.

TNA/PROB/11/1076/102, Will of Richard Peirson, 1781.

1.3. Essex Archives.

SEAX/D/DU/621/1, West Ham Waterworks, articles of agreement, 1745.

1.4. Westminster Archives.

F2489, Hyde Park Waterworks, list of tenants, 1678.

1.5. Parliamentary Papers.

Census of England and Wales, 1801, *Enumeration abstract, Middlesex*, PP (497), pp. 207-16.

Census of England and Wales, 1811, *Enumeration abstract, Middlesex*, PP (497), pp. 192-9.

Journals of the House of Commons, volume XIX, Nov. 1718 – March 1721, BL/BS/Ref/6.

Journals of the House of Commons, volume XX, Oct. 1721 – May 1727, BL/BS/Ref/6.

Journals of the House of Commons, volume XXX, Jan. 1765 – Sep. 1766, BL/BS/Ref/6.

Minutes of evidence taken before the select committee on the supply of water to the metropolis, PP 1821 (706).

23 Hen VIII c. 5, *The bill of sewers*, 1531. BL/BS/Ref/20.

3 Jac I c. 14, *Statute of sewers*, 1605. BL/BS/Ref/20.

19 Car II c. 3, *Act for rebuilding the City of London*, 1667. BL/BS/Ref/20.

7 An c. 17, *Act for better preventing mischiefs that may happen by fire*, 1708. BL/BS/Ref/20.

Water Industry Act, 1991, c. 56.

1.6. Cartographic material.

Cary, J., *Cary's New and Accurate Plan of London and Westminster, the Borough of Southwark and parts adjacent* (London, 1787).

Horwood, R., *Plan of the Cities of London and Westminster and the Borough of Southwark and Parts adjoining, Shewing every House. By R. Horwood* (London, 1792-9).

Morgan, W., *London &c Actually surveyed* (London, 1682).

Richardson, G., *Large plan of an estate called the Marylebone Park Farm, belonging to the Crown* (1794). British Library, Crace collection, Portfolio XIV, no. 28.

Rocque, J., *A Plan of the Cities of London and Westminster, and Borough of Southwark; with the Contiguous Buildings; From an actual Survey, taken by John Rocque, Land Surveyor, and Engraved by John Pine, Bluemantle Pursuivant of Arms, and Chief Engraver of Seals, &c To His Majesty* (London, 1746).

Stockdale, J., *A New Plan of London, XXIX Miles in Circumference; engraved by S.J. Neele* (London, 1797).

Thompson, J., *Large plan in two sheets of the Parish of St. Pancras, from a minute and concrete survey* (1804), British Library, Crace collection, Portfolio XIV, no. 43.

1.7. Newspapers.

All Alive and Merry or the London Daily Post, 18 April 1740.

‘*An anti-monopolist*’, letter in *Gazetteer and New Daily Advertiser*, 27 Feb. 1767.

Anonymous, letter in *Gazetteer and New Daily Advertiser*, 11 Aug. 1772.

‘*Aquae Vindex*’, letter in *Morning Post and Daily Advertiser*, 14 Dec. 1775.

B.Y.Z., letter in *Lloyd’s Evening Post*, 5 Dec. 1764.

Clerk to Shadwell Waterworks, letter in *Lloyd's Evening Post*, 6 Jan. 1759.

'Curtius', letter in *Morning Post and Daily Advertiser*, 15 Dec. 1775

Daily Courant, 4 May 1717; 6 Nov. 1718.

Daily Journal, 11 July 1733.

D.L., letter in *Gazetteer and New Daily Advertiser*, 23 Feb. 1767.

Gazetteer and London Daily Advertiser, 4 Jan. 1759; 21 Jan. 1763.

Gazetteer and New Daily Advertiser, 10 Feb 1767; 30 March 1767; 24 July 1767; 4 July 1767.

'Hydraulogos', letter in *Gazetteer and New Daily Advertiser*, 18 Sept 1772.

Lloyd's Evening Post, 26 Jan. 1795.

London Chronicle, 13 Jan. 1776; 3 June 1780.

London Courant and Westminster Chronicle, 26 July 1780.

London Evening Post, 9 Nov. 1731; 24 Jan. 1767; 26 March 1767.

London Gazette, 15 June 1779.

L.S., letter in *Gazetteer and New Daily Advertiser*, 10 Feb. 1767

Morning Post and Daily Advertiser, 30 Jan. 1776; 14 Aug. 1793.

Mylne, letter in the *Public Advertiser* of 10 July 1767.

New Lloyd's Evening Post, 2 Jan. 1799.

O., letter in the *Gazetteer and London Daily Advertiser*, 6 Jan. 1763.

Post Man and the Historical Account, 10 Jan. 1716.

Public Advertiser, 21 Jan. 1763; 20 April 1765; 15 Jan. 1789.

Secretary to London Bridge Waterworks, letter in *General Advertiser*, 30 Mar. 1748.

Star, 22 Jan. 1795.

The Times, 25 April 1798

True Briton, 15 Nov. 1798.

W.E., letter in the *Gazetteer and London Daily Advertiser*, 28 Dec. 1762.

West Ham Waterworks, advertisement in *Public Advertiser*, 28 Nov. 1767.

World, 13 Jan. 1789.

Yeoman, T., letter in the *London Evening Post*, 22 Nov. 1765.

York Buildings Waterworks, letter in *Public Advertiser*, 21 Jan. 1763

2. Secondary sources.

2.1. Unpublished.

Cummings, A.J.G., 'The York Buildings Company, a case study in eighteenth century corporation management' (PhD thesis, University of Strathclyde, 1980).

Hakewill, W.R.H., 'Hampstead Water Works, office and company, 1589-1859' (Unpublished manuscript, 1984, held at LMA/COL/SJ/16/34).

Hillier, J.O., 'Constructing London's water supply: a study of engineering and modernity' (PhD thesis, University College London, 2009).

Shirata, Y., 'The provision of sewers in West London, 1659-1761' (MPhil thesis, University of Leicester, 2000).

Thomas, J.H., 'Thomas Neale, a seventeenth-century projector' (PhD thesis, Southampton University, 1979).

2.2. Sources published before 1900.

Anonymous, *The York-Buildings Dragons* (London, 1726).

Archenholz, J.W. von, *A picture of England* (London, 1797).

C.M., *The law of sewers* (London, 1762).

Corporation of London, *An Act (of 1667) for Preventing and suppressing Fires within the City of London and Liberties thereof* (London, Clark, 1676).

Defoe, D., *A tour thro' the whole island of Britain* (London, 1727).

Du Boccage, Mme, *Letters concerning England, Holland, and Italy* (London, 1770).

Efford, W., *A Scheme For the Better Supplying this Metropolis With Sweet and Wholesome Water from the River Coln* (London, 1764).

Fletcher, J., 'History and statistics of the present system of sewerage in the Metropolis', *Journal of the statistical society of London*, 7 (1844), pp. 143-170.

Grosley, P.J., *A tour to London: or, new observations on England, and its inhabitants* (Dublin 1772).

Hargrave, F., *The laws of sewers* (London, 1732).

Hatton, E., *A new view of London* (London, 1708).

Kennedy, G.G. and Sandars, J.J., *The law of land drainage and sewers* (London, Waterlow Bros and Layton, 1884).

Matthews, W., *Hydraulia* (London, Simpkin, Marshall, and Co, 1835).

Mayhew, H., *London labour and the London poor: a cyclopedia of the condition and earnings of those that will work, those that cannot work, and those that will not work, volume 1* (London, 1861).

Robins, J., *A Bone to Pick, Recommended to the Several Water Companies of this Metropolis; Or a Check to Avarice, Tyranny and Oppression, in Two Parts* (London, 1790).

Smith, A., *The Wealth of Nations* (London, 1776).

Smolett, T, *The Expedition of Humphry Clinker* (London, 1771).

Swift, J., *A description of a city shower* (London, 1710).

Woolrych, H.W., *A treatise on the law of waters, and of sewers* (London, Saunders and Benning, 1830).

2.3. Published after 1900.

Akan, A.O. and Houghtalen, R.J., *Urban hydrology, hydraulics, and stormwater quality* (London, Wiley, 2003).

Allen, D.W., *The institutional revolution, measurement and the economic emergence of the modern world* (Chicago, University of Chicago Press, 2012).

Allen, R., *The British Industrial Revolution in global perspective* (Cambridge, Cambridge University Press, 1992).

Andrew, D.T., *Philanthropy and police, London charity in the eighteenth century* (Princeton, Princeton University Press, 1989).

Appleby, J.H., 'Rowley, John (c.1668–1728)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn. Jan. 2008):
[<http://www.oxforddnb.com/view/article/37919>, accessed 5 July 2012].

Barker, F. and Jackson, P., *The history of London in maps* (London, Barrie and Jenkins, 1990).

Barles, S., 'A metabolic approach to the city: nineteenth and twentieth century Paris', in D. Schott, B. Luckin, and G. Massard-Guilbaud, eds., *Resources of the city* (2005), pp. 28-47.

Becker, G., 'A theory of the allocation of time', *The Economic Journal*, 75 (1965), pp. 493-517.

Bell, W.G., 'The birth of the London rate-payer', *History*, 12 (1927), pp. 117-129.

Berg, M. and Eger, E., 'The rise and fall of the luxury debates', in M. Berg and E. Eger, eds., *Luxury in the eighteenth century, debates, desires and delectable goods* (Basingstoke, Palgrave Macmillan, 2003), pp. 7-27.

Black, J., *The English press in the eighteenth century* (London, Croom Helm, 1987).

Blackstone, G.V., *A history of the British fire service* (London, Routledge, 1996).

Boyden, S., 'Nature, society, history and social change', *Innovation*, 14 (2001), pp. 103-116.

Bowen, H.V., 'Colebrooke, Sir George, second baronet (1729–1809)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn. Jan. 2008):
[<http://www.oxforddnb.com/view/article/37301>, accessed 8 July 2012].

Brazell, J.H., *London weather* (London, Meteorological Office, 1968).

Breen, T.H., 'The meanings of things: interpreting the consumer economy in the eighteenth century', in J. Brewer and R. Porter, eds., *Consumption and the world of goods* (London, Routledge, 1993), pp. 249-260.

Brewer, J., *The sinews of power: war, money, and the English state, 1688-1783* (London, Unwin Hyman, 1989).

Briggs, A., *The power of steam* (London, Michael Joseph, 1982).

Brooks, C.E.P. and Glasspoole, J., *British floods and droughts* (London, Ernest Benn Limited, 1928).

Buchan, S., *The water supply of the county of London from underground sources* (London, Geological Survey, 1938).

Buchanan, R.A. and Watkins, G., *The industrial archaeology of the stationary steam engine* (London, Allen Lane, 1976).

Byrne, T., *Local government in Britain* (London, Penguin Books, 2000).

Calhoun, C., 'Introduction: Habermas and the public sphere', in C. Calhoun, ed., *Habermas and the public sphere* (Baskerville, Massachusetts Institute of Technology, 1992), pp. 1-48.

Carruthers, B., *City of capital: politics and markets in the English financial revolution* (New Jersey, Princeton University Press, 1996).

Chandler, A., *The visible hand: the managerial revolution in American business* (Cambridge, Harvard University Press, 1977).

Chandler, A., *Scale and scope: the dynamics of industrial capitalism* (Cambridge, Harvard University Press, 1990).

Chichester, H.M., 'Molesworth, Richard, third Viscount Molesworth (1680–1758)', in J. Spain, ed., *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn. Oct. 2007): [<http://www.oxforddnb.com/view/article/18900>, accessed 23 June 2009].

Clark, P., *British clubs and societies, 1580-1800* (Oxford, Clarendon Press, 2000).

- Clout, H.D., *The Times London history atlas* (London, Harper Collins, 1997).
- Cook, H.J., 'Colbatch, Sir John (bap. 1666?, d. 1729)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn. Jan 2008):
[<http://www.oxforddnb.com/view/article/5833>, accessed 23 June 2009].
- Cromar, P., 'The coal industry on Tyneside, 1771-1800, oligopoly and spatial change', *Economic Geography*, 53 (1977), pp. 79-94.
- Cronon, W., *Nature's metropolis: Chicago and the Great West* (New York, Norton and Co, 1991).
- Darby, H.C., *The draining of the fens* (Cambridge, Cambridge University Press, 1940).
- Darlington, I. 'The London commissioners of sewers and their records', in T. Ranger, ed., *Prisca Munimenta: studies in archival & administrative history* (London, University of London Press, 1973), pp. 282-98.
- De Vries, J., *The industrious revolution, consumer behaviour and the household economy, 1650 to the present* (Cambridge, Cambridge University Press, 2008).
- Dickinson, H. W., *Water supply of Greater London* (London, The Courier Press, 1954).
- Dickson, P.G.M., *The Financial Revolution in England: a study in the development of public credit, 1688-1760* (London, Melbourne, 1967).
- Ellison, R.A., *Geology of London* (Nottingham, Keyworth, 2004).
- Fischer-Kowalski, M. and Huttler, W., 'Society's metabolism, the intellectual history of materials flow analysis, part II, 1970-1998', *Journal of Industrial Ecology*, 2 (1998), pp. 107-136.

Fisher, D.R., 'Loveden, Edward Loveden (?1751-1822), of Buscot Park, Berks.', in *The History of Parliament: the House of Commons 1790-1820* (Woodbridge, Boydell and Brewer, 1986), online edn.: [<http://www.historyofparliamentonline.org/volume/1790-1820/member/loveden-edward-loveden-1751-1822>, accessed 9 July 2012].

Fordham, H.G., *John Cary – engraver, map, chart, and print-seller and globe-maker, 1754 to 1835* (Cambridge, Cambridge University Press, 1925).

Foxell, S., *Mapping London: making sense of the city* (London, Black Dog Publishing, 2007).

Galili, R., *Arnos Grove and the Walker Family* (London, Southgate District Civic Trust, 2008).

Gandy, M., 'The Paris sewers and the rationalization of urban space', *Transactions of the Institute of British Geographers*, 24 (1999), pp. 23-44.

Gandy, M., 'Rethinking urban metabolism: water, space and the modern city', *City*, 8 (2004), pp. 371-87.

Geekie, A., 'Alexander Geekie to John Locke: Wednesday, 23 December 1702 — [letter]', in R. McNamee et al, ed., *Electronic Enlightenment* (Oxford, University of Oxford Press), online edn.: [http://0-www.e-enlightenment.com/catalogue/ulrsls.lon.ac.uk/item/lockjoOU0070724_1key001cor/, accessed 30 Nov. 2012].

George, D.M., *London life in the eighteenth century* (Chicago, Academy Chicago, 1984).

Golinski, J., *British weather and the climate of Enlightenment* (Chicago, University of Chicago Press, 2007).

Graham-Leigh, J., *London's water wars: the competition for London's water supply in the nineteenth century* (London, Francis Boutle, 2000).

Gray, R., *A history of London* (New York, Taplinger, 1978).

Griffin, C.J., 'Becoming private property: custom, law, and the geographies of 'ownership' in 18th- and 19th-century England', *Environment and Planning A*, 42 (2010), pp. 747-762.

Guillery, P., *The small house in eighteenth-century London* (New Haven, Yale University Press, 2004).

Gurnell, A.M., Peiry, J.-L., and Petts, G.E., 'Using historical data in fluvial geomorphology', in M. Kondolf and H. Piégay, eds., *Tools in geomorphology* (London, Wiley, 2003), pp. 77-103.

Habermas, J., *The structural transformation of the public sphere* (Cambridge, MIT Press, 1991).

Halliday, S., *The great stink of London: Sir Joseph Bazalgette and the cleansing of the Victorian metropolis* (Stroud, Sutton Publishing, 1999).

Hancock, D., *Citizens of the World, London merchants and the integration of the British Atlantic community, 1735-1785* (Cambridge, Cambridge University Press, 1995).

Hanley, J.G., 'The Metropolitan Commissioners of Sewers and the law, 1812-1847', *Urban History*, 33 (2006), pp. 350-68.

Hardy, A., 'Parish pumps to private pipes: London's water supply in the nineteenth century', *Medical History*, supplement no. 11 (1991), pp. 76-93.

Harley, J.B., *The new nature of maps: essays in the history of cartography* (London, John Hopkins University Press, 2001).

Hay, D., 'Poaching and the game laws on Cannock Chase', in D. Hay et al, eds., *Albion's fatal tree* (Harmondsworth, Penguin Books, 1977), pp. 189-254.

Heilbroner, R.L., *The worldly philosophers* (London, Penguin Press, 1980).

Hillier, J., 'The rise of constant water in nineteenth-century London', *The London Journal*, 36 (2011), pp. 37-53.

Hills, R.L., *James Watt, volume 2: the years of toil, 1775-1785* (Ashbourne, Landmark Publishing, 2005).

Holloway, S., *Courage High! A history of firefighting in London* (London, HMSO, 1992).

Howgego, J., *Printed maps of London, circa 1553-1850* (Folkestone, Dawson, 1978).

Hughes, T.P., *Networks of power: electrification in western society, 1880-1930* (Baltimore, Johns Hopkins University Press, 1993).

Humpherus, H., *History of the origin and progress of the Company of Watermen and Lightermen of the river Thames with numerous historical notes, Volume II* (Wakefield, E.P. Microfilm, 1981).

Hutchison, T., *Before Adam Smith — the emergence of political economy, 1662-1776* (Oxford, Basil Blackwell, 1988).

Hyde, R., 'William Morgan's survey of London, 1682', in *Facsimile of London &c Actually surveyed* (Lympe Castle, Harry Margary, 1977).

Hyde, R., 'The making of John Rocque's map', in *The A to Z of Georgian London* (Lympe Castle, Harry Margary, 1982), pp. v-viii.

Hyde, R., 'Portraying London mid-century – John Rocque and the brothers Buck', in S. O'Connell, ed., *London 1753* (London, British Museum Press, 2003).

Inwood, S., *A history of London* (Basingstoke, Papermac, 2000).

Jefferson-Smith, P., 'Before Bazalgette: the Surrey and Kent Commission of Sewers, 1800-1847', *Transactions of the Newcomen Society*, 74 (2004), pp. 131-46.

Jenks, M., Burton, E., and Williams, K., eds., *The compact city: a sustainable urban form?* (London, Spon Press, 1996).

Jenner, M.S.R., 'From conduit community to commercial network? Water in London, 1500-1725', in P. Griffiths and M.S.R. Jenner, eds., *Londinopolis: essays in the cultural and social history of early modern London* (Manchester, Manchester University Press, 2000), pp. 250-72.

Jones, E.L., Porter, S., and Turner, M., *A gazetteer of English urban fire disasters* (Norwich, Historical Geography Research Series, 1984).

Jørgensen, D., 'Cooperative sanitation: managing streets and gutters in late medieval England and Scandinavia', *Technology and Culture*, 49 (2008), pp. 547-567.

Jørgensen, D., 'Local government responses to urban river pollution in late medieval England', *Water History*, 2 (2010), pp. 35-52.

Kaika, M., *City of flows: modernity, nature, and the city* (London, Routledge, 2005).

Kanefsky, J. and Robey, J., 'Steam engines in 18th-century Britain: a quantitative assessment', *Technology and Culture*, 21 (1980), pp. 161-186.

Lamb, H.H., *Climate, history and the modern world* (London, Methuen, 1982).

Laxton, P., 'Richard Horwood's map and the face of London, 1799-1819', in *The A to Z of Regency London* (Lympe Castle, Harry Margary, 1985), pp. v-xiv.

Lefebvre, H., *The production of space* (Oxford, Wiley, 1992).

Lewis, D., "'For the poor to drink and the rich to dress their meat": the first London water conduit', *Transactions of the London and Middlesex Archaeological Society*, 55 (2004), pp. 39-68.

Lieshout, C. van, 'Floods and flood response in eighteenth-century London', in J.A. Galloway, ed., *Tides and Floods, new research on London and the tidal Thames from the middle ages to the twentieth century* (London, Centre for Metropolitan History, 2010), pp. 29-43.

Lindberg, F. and Grimmond, C.S.B., 'Nature of vegetation and building morphology characteristics across a city: influence on shadow patterns and mean radiant temperatures in London', *Urban Ecosystems*, 14 (2011), pp. 617-634.

Linton, J., *What is water? The history of a modern abstraction* (Vancouver, UBC press, 2010).

Lloyd, S., *Charity and poverty in England, c. 1680-1820* (Manchester, Manchester University Press, 2009).

Loftus, A., 'Thinking relationally about water: review based on Linton's What is water', *Geographical Journal*, 177 (2011), pp. 186-188.

Luckin, B., *Pollution and control, a social history of the Thames in the nineteenth century* (Bristol, Adam Hilger, 1986).

Luckin, B., 'Pollution in the city', in M. Daunton, ed., *The Cambridge urban history of Britain, vol III, 1840-1950* (Cambridge, Cambridge University Press, 2000), pp. 207-228.

- Magnusson, R.J., *Water technology in the Middle Ages, monasteries and waterworks after the Roman Empire* (London, Johns Hopkins University Press, 2001).
- Massard-Guilbaud, G. and Thorsheim, P., 'Cities, environment, and European history', *Journal of Urban History*, 33 (2007), pp. 691-701.
- Massard-Guilbaud, G. and Mosley, S., 'Breaking down borders: integrating the social and environmental in history', in G. Massard-Guilbaud and S. Mosley, eds., *Common ground: integrating the social and environmental in history* (Newcastle upon Tyne, Cambridge Scholars Publishing, 2011), pp. 1-15.
- Mathias, P., *The brewing industry in England, 1700-1830* (Cambridge, Cambridge University Press, 1959).
- McKendrick, N., 'The consumer revolution of eighteenth-century England', in N. McKendrick, J. Brewer, and J.H. Plumb, eds., *The birth of a consumer society, the commercialization of eighteenth-century England* (London, Hutchinson & Co, 1982), pp. 9-33.
- Melosi, M.V., 'The place of the city in environmental history', *Environmental History Review*, 17 (1993), pp. 1-23.
- Melosi, M.V., *The sanitary city* (Baltimore, Johns Hopkins University Press, 2000).
- Mercer, M.J., 'Clark, Richard (1739–1831)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn. May 2006):
[<http://www.oxforddnb.com/view/article/5470>, accessed 8 July 2012].
- Metropolitan Water Board, *The water supply of London* (London, Staples Press, 1949).
- Miller, P.N., *Defining the common good, empire, religion and philosophy in eighteenth-century Britain* (Cambridge, Cambridge University Press, 1994).

- Millward, B., 'Emergence of gas and water monopolies in nineteenth-century Britain: contested markets and public control', in J. Foreman-Peck, ed., *New perspectives on the late Victorian economy* (Cambridge, Cambridge University Press, 1991), pp. 96-124.
- Mokyr, J., *The enlightened economy, an economic history of Britain, 1700-1850* (London, Yale University Press, 2009).
- Mosley, C., ed., *Burke's Peerage, Baronetage & Knightage, 107th edition, volume 2* (Wilmington, Delaware, Burke's Peerage Ltd, 2003).
- North, D.C. and Weingast, B.R., 'Constitutions and commitment: the evolution of institutions governing public choice in seventeenth-century England', *Journal of Economic History*, 49 (1989), pp. 803-32.
- Novak, M.E., 'Introduction', in M.E. Novak, ed., *The age of projects* (Toronto, University of Toronto Press, 2008), pp. 3-26.
- Ogborn, M., *Spaces of modernity: London's geographies, 1680-1780* (New York, The Guilford Press, 1998).
- Parsons, W., *The power of the financial press* (Aldershot, Edward Elgar, 1989).
- Pearson, R., *Insuring the Industrial Revolution: fire insurance in Great Britain, 1700-1850* (Aldershot, Ashgate, 2004).
- Pocock, J.G.A., *Virtue, commerce, and history: essays on political thought and history, chiefly in the eighteenth century* (Cambridge, Cambridge University Press, 1985).
- Polanyi, K., *The great transformation, the political and economic origins of our time* (Boston, Beacon Paperback, 1956).

Poovey, M., *Genres of the credit economy* (Chicago, University of Chicago Press, 2008).

Porter, D.H., *The Thames embankment: environment, technology, and society in Victorian London* (Akron, University of Akron Press, 1998).

Porter, R., *Enlightenment, Britain and the creation of the modern world* (London, Penguin Press, 2000).

Porter, S., *The Great Fire of London* (Stroud, Sutton, 2001).

Randall, A. and Charlesworth, C., eds., *Markets, market culture and popular protest in eighteenth-century Britain and Ireland* (Liverpool, Liverpool University Press, 1996).

Reddaway, T.F., *The rebuilding of London after the Great Fire* (London, Edward Arnold, 1940).

Roberts, G., *From Chelsea to Cairo, Taylor-made water through eleven reigns and in six continents* (London, Thomas Telford Publishing, 2006).

Rosen, C. M. and Tarr, J.A., eds., The environment and the city: a special issue of the *Journal of Urban History*, 20 (1994).

Roseveare, H., *The financial revolution, 1660-1760* (London, Longman, 1991).

Rudden, B., *The New River: a legal history* (Oxford, Clarendon Press, 1985).

Rudé, G., *Hanoverian London, 1714-1808* (London, Secker and Warburg, 1971).

Schwarz, L., 'Social class and social geography: the middle classes in London at the end of the eighteenth century', in P. Borsay, ed., *The eighteenth-century town: a reader in English urban history, 1688-1820* (London, Longman, 1990), pp. 315-337.

- Schwarz, L., *London in the age of industrialisation: entrepreneurs, labour force and living conditions in the capital, 1700-1850* (Cambridge, Cambridge University Press, 1992).
- Schott, D. 'Resources of the city: towards a European urban environmental history', in D. Schott, B. Luckin, and G. Massard-Guilbaud, eds., *Resources of the City: contributions to an environmental history of modern Europe* (Aldershot, Ashgate, 2005), pp. 1-27.
- Secombe, T., 'Negus, Francis (bap. 1670, d. 1732)', in C. Clark, ed., *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, 2004):
[<http://www.oxforddnb.com/view/article/19856>, accessed 23 June 2009].
- Serner, S.N., 'The construction of the modern city and the management of water resources in Italy, 1880-1920', *Journal of Urban History*, 33 (2007), pp. 813-827.
- Sheail, J., 'Underground water abstraction: indirect effects of urbanization on the countryside', *Journal of Historical Geography*, 8 (1982), pp. 395-408.
- Sheppard, F.H.W., 'Kingly and Carnaby Street Area', in F.H.W. Sheppard, ed., *Survey of London: volumes 31 and 32: St James Westminster, Part 2* (London, Institute of Historical Research, 1963), pp. 176-195, online edn.:
[<http://www.british-history.ac.uk/report.aspx?compid=41470>, accessed 29 August 2012].
- Slack, P., *Reformation to improvement, public welfare in early modern England* (Oxford, Clarendon Press, 1999).
- Smellie, K. B., *A history of local government* (London, George Allen, 1968).
- Smout, T.C., *Exploring environmental history, selected essays* (Edinburgh, Edinburgh University Press, 2009).

Sörlin, S. and Warde, P., 'The problem of the problem of environmental history: a re-reading of the field', *Environmental History*, 12 (2007), pp. 107-130.

Spain, J., 'Fane, John, seventh earl of Westmorland (bap. 1686, d. 1762)', in *Oxford Dictionary of National Biography* (Oxford, Oxford University Press, online edn. May 2009): [<http://www.oxforddnb.com/view/article/9134>, accessed 5 July 2012].

Spate, O.H.K., 'The growth of London, A.D. 1660-1800', in H.C. Darby, ed., *An historical geography of England before A.D. 1800* (Cambridge, Cambridge University Press, 1936), pp. 529-48.

Spence, C., *London in the 1690s, a social atlas* (London, Institute of Historical Research, 2000).

Spencer, H., 'Holford, George Peter (1767-1839), of 15 Bolton Street, Mdx. and Weston Birt, Glos.', in D.R. Fisher, ed., *The history of Parliament: the House of Commons 1820-1832* (Cambridge, Cambridge University Press, 2009), online edn.: [<http://www.historyofparliamentonline.org/volume/1820-1832/member/holford-george-1767-1839>, accessed 9 July 2012].

Stedman Jones, G., *An end to poverty? A historical debate* (London, Profile Books, 2004).

Steinberg, T., *Nature incorporated, industrialization and the waters of New England* (Cambridge, Cambridge University Press, 1991).

Stewart, L., *The rise of public science: rhetoric, technology, and natural philosophy in Newtonian Britain, 1660-1750* (Cambridge, Cambridge University Press, 1992).

Stiglitz, J.E. and Walsh, C., *Principles of microeconomics* (London, Norton, 2006).

Summerson, J., *Georgian London* (Harmondsworth, Penguin Press, 1962).

Sunderland, D., '“A monument to defective administration”? The London Commissioners of Sewers in the early nineteenth century', *Urban History*, 26 (1999), pp. 349-72.

Swyngedouw, E., 'Modernity and hybridity: nature, regeneracionismo, and the production of the Spanish waterscape, 1890-1930', *Annals of the Association of American Geographers*, 89 (1999), pp. 443-465.

Swyngedouw, E., 'The political economy and political ecology of the hydro-social cycle', *Journal of contemporary water research and education*, 142 (2009), pp. 56-60.

Swyngedouw, E., *Social power and the urbanization of water* (Oxford, Oxford University Press, 2004).

Tarr, J.A., 'Transforming an energy system: the evolution of the manufactured gas industry and the transition to natural gas in the United States, 1807-1954', in O. Coutard, ed., *The governance of large technical systems* (London, Routledge, 1999), pp. 19-37.

Tarr, J.A. and Stine, J., 'At the intersection of histories: technology and the environment', *Technology and culture*, 39 (1998), pp. 601-640.

Taylor, V. and Trentmann, F., 'Liquid politics: water and the politics of everyday life in the modern city', *Past and Present*, 211 (2011), pp. 199-241.

Thompson, E.P., 'The moral economy of the English crowd in the eighteenth century', *Past and present*, 50 (1971), pp. 76-136.

Thorne, R.G., 'Edwards (afterwards Noel), Gerard Noel (1759-1838), of Exton Park, Rutland', in R. Thorne, ed., *The history of Parliament: the House of Commons 1790-1820* (Woodbridge, Boydell and Brewer, 1986), online edn.:
[[http://www.historyofparliamentonline.org/volume/1790-1820/member/edwards-\(afterwards-noel\)-gerard-noel-1759-1838](http://www.historyofparliamentonline.org/volume/1790-1820/member/edwards-(afterwards-noel)-gerard-noel-1759-1838), accessed 9 July 2012].

- Trentmann, F. and Taylor, V. 'From users to consumers, water politics in nineteenth-century London', in F. Trentmann, ed., *The making of the consumer, knowledge, power and identity in the modern world* (Oxford, Berg, 2006), pp. 53-79.
- Tynan, N., 'London's private water supply, 1582-1902', in P. Seidenstat, D. Haarmeyer, and S. Hakim, eds., *Reinventing water and wastewater systems: global lessons for improving water management* (New York, Wiley, 2002), pp. 341-60.
- Tynan, N., 'Mill and Senior on London's water supply: agency, increasing returns and natural monopoly', *Journal of the History of Economic Thought*, 29 (2007), pp. 49-65.
- Wales-Smith, B.G., 'Monthly and annual totals of rainfall representative of Kew, Surrey, from 1697 to 1970', *Meteorological Magazine*, 100 (1971), pp. 345-362.
- Ward, R., *London's New River* (London, Historical Publications, 2003).
- Ware, A. and Goodin, R.E., 'Introduction', in A. Ware and R.E. Goodin, eds., *Needs and welfare* (London, SAGE publications, 1990), pp. 1-11.
- Webb, B. and Webb, S., *English local government from the Revolution to the Municipal Corporations Act, volume 4: statutory authorities for special purposes* (London, Longmans, Green, and Co, 1922).
- Weinstein, R., 'New urban demands in early modern London', in R. Porter, ed., *Living and dying in London* (London, Wellcome Institute for the History of Medicine, 1991), pp. 29-40.
- Whiston Spirn, A., *The granite garden: urban nature and human design* (New York, Basic Books, 1984).

White, J., *London in the eighteenth century: a great and monstrous thing* (London, the Bodley Head, 2012).

Winiwarter V. and Schmid, M., 'Umweltgeschichte als Untersuchung sozionaturaler Schauplätze? Ein Versuch, Johannes Colers 'Oeconomia' umwelthistorisch zu interpretieren', in T. Knopf, ed., *Umweltverhalten in Geschichte und Gegenwart* (Tübingen, Attempto Verlag, 2008), pp. 158-173.

Withers, C.W.J., *Placing the Enlightenment, thinking geographically about the Age of Reason* (Chicago, University of Chicago Press, 2007).

Wittfogel, K.A., *Oriental despotism: a comparative study of total power* (New York, Random House, 1957).

Worster, D., *Rivers of empire: water, aridity, and the growth of the American West* (Oxford, Oxford University Press, 1985).

Wynne, S., 'Berners, William (1679-1712), of Moore Place, Much Hadham, Herts.', in D. Hayton, E. Cruickshanks, and S. Handley, eds., *The history of Parliament: the House of Commons 1690-1715* (Woodbridge, Boydell and Brewer, 2002), online edn.: [<http://www.historyofparliamentonline.org/volume/1690-1715/member/berniers-william-1679-1712>, accessed 8 July 2012].

Yamamoto, K., 'Piety, profit and public service in the financial revolution', *English Historical Review*, 74 (2011), pp. 806-834.